AGRICULTURE

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AGRICULTURE

FOR THE

KANSAS COMMON SCHOOLS

COMPILED AND ARRANGED BY

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PREFACE

Agriculture is the basic industry of Kansas. The way the farms of Kansas are tilled in the future depends on the way agriculture is taught in the schools now.

Not only, however, is this book intended to make more effective the teaching of agriculture in the schools of the state, but the amount of material applying directly to Kansas conditions should make the book also a valuable reference work for the farmer. Because of the widely varying conditions in the state, the teacher should emphasize those chapters the subject matter of which is of greatest importance in the local community.

The book was prepared by the college and experiment station staffs of the Kansas State Agricultural College.

Special acknowledgment is due President H. J. Waters, Dean W. M. Jardine, and Dean J. T. Willard for advice and assistance in the preparation of the book.

The names of the authors of the chapters are given in the table of contents. Unless otherwise acknowledged, photographs were supplied by the authors of the respective chapters. The subject matter as originally furnished has been rearranged for the sake of uniformity and better adaptation to the needs of the public schools.

The compilers also desire to acknowledge their indebtedness to N. A. Crawford, Assistant Professor of the English Language in charge of the Department of Industrial Journalism, for expert editorial service in the preparation of this volume.

LELAND EVERETT CALL
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INTRODUCTION

Why we Study Agriculture

When man first began raising plants and caring for animals is not known. It must have been long before the time of the most ancient people of whom we have record. The earliest farming must have been very simple. It consisted probably in scratching up the soil a very little with a stick and planting the seed to grow as best it could, and finally harvesting a small crop of very poor grain or fruit. Men also watched the animals to keep them from straying and from being stolen by other men or killed by wild beasts. After long ages man learned to build inclosures for his live stock and to select the gentler and better animals to increase his herds. This was the first step toward scientific agriculture. Long before Christ was born, men learned to hitch oxen, horses, and camels to rough wooden plows, which tore up and loosened the soil after a fashion. Probably even before this, man had learned to keep the weeds down and to cultivate the soil during the growing season. He also learned to select the better grains and fruits for seed, and travelers sometimes brought home with them the seeds of new plants. Some of the earliest lessons man learned about agriculture were, first, to save the seed from the best plants, and to select the best and gentlest animals to increase his herds; second, how better to till the soil and to guard and feed his animals.

There is no doubt that with such care plants and animals improved greatly. Grains, such as wheat and

barley, and fruits, melons, roots, and vegetables, grew larger and more palatable. The cattle, horses, and other stock must have changed from small, narrow, bony, long-haired, scrubby animals to larger, better-formed, more useful live stock.

After the thirteenth century, parts of the world, especially of Europe, became densely populated. With the growth in population and the demand for more food, new fields were continually opened up. When a field had lost its fertility it was abandoned, and another field was cleared and cultivated. When all the lands were being used and still not enough food was produced, there was great suffering, and many poor people starved.

During the seventeenth century America was colonized, and soon food was sent to Europe in considerable quantities. About this time corn, which had been used for centuries by the Indians alone, began to be used by civilized people, the wooden plows were improved, and better live stock was produced. But with all these changes food still remained scarce.

It had long been noticed that better tillage produced better crops. Many persons began writing about tillage, and finally, in 1733, an Englishman named Jethro Tull published a book called "The Horse-hoing Husbandry," in which he advocated better and more regular tillage, as a necessary step in securing large yields of crops.

The need for cheap food in the eighteenth and nineteenth centuries led learned men in colleges and universities to begin studying the problems of agriculture. That meant the real beginning of scientific agriculture. What these scientists and the farmers working together have discovered makes up what we are to learn about agriculture.

In our study of agriculture we are always to look for

two things: first, the best method of doing a thing; second, the reasons for doing the thing in that way.

In a very short time we are to learn easily the following things, which mankind has learned with much trouble and at great cost:

1. How to produce cheaply larger amounts and a better quality of grain, feed, fruits, and vegetables.

2. How to keep the soil in the best condition for growing large crops at the least expense, and how to preserve rather than waste the fertility of the soil.

3. How through better breeding, feeding, and housing to produce better live stock, and better live-stock products, such as eggs, milk, butter, and wool.

4. How to make the business of farming more profitable and more attractive.

5. How to make the farmer's home a pleasant and convenient place in which to live.

6. How to make the neighborhood a desirable place morally and socially, as well as an efficient business community.

7. How to coöperate with other farmers and develop such a common feeling among farmers as exists among doctors, lawyers, merchants, or laboring men.

CHAPTER I

HOW PLANTS ARE BUILT

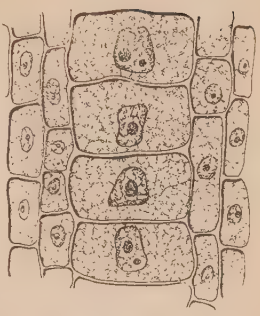
Plants are the great food makers of the earth. They alone have the power to take from air and soil and water different materials, which they put together, and from which they make food for man and animals. If it were not for plants, therefore, man and animals could not live upon the earth.

The Parts of a Plant. All plants of greatest importance are made up of four parts: the roots, the stems, the leaves, and the flowers and fruits. At some stage in the plant's life some of these parts may be missing. In winter many trees are without leaves. Certain other plants lose both stems and leaves during the winter, at least as far down as the surface of the ground. In others, roots, stems, and leaves all die at the end of the growing season, as is the case with corn, Russian thistle, pigweed, sunflower, foxtail, and crab grass. Some plants, such as winter wheat and rye, if their seed is sown in the fall, remain alive and green all winter, but die the following summer, after producing their seeds.

Some plants live only two years. During the first year their leaves make food, which is stored up in roots, bulbs, and the like; the second season, both leaves and a flower stalk are borne. After the seeds are produced, the plant dies. Most of the root crops, such as beets, turnips, parsnips, and carrots, are plants of this kind. Onions also grow in this way. If the onion bulbs that grow from the seed

the first season are planted the next year, they will produce flower stalks, will bear seeds, and will then die.

Some plants, such as goldenrod, ironweed, and alfalfa, die only to the ground, and may continue to live through several or many years.



Plant cells. The large, round body in the center of each cell is called the nucleus. It might be called the engine of the cell.

The Structure of Plants. Though plants differ widely in behavior and even in appearance, the structure of one plant, nevertheless, very much resembles that of another. Thus, we have the roots going down into the soil, and the stem holding the leaves up to the air. The stem and the roots are made up of a framework of woody tissue. The amount of wood differs greatly in different plants and at different times of the year. Asparagus, for example, has very little wood in its stems when they are gathered in the spring, but later, in the summer, when it has grown tall and coarse, the stems are very woody. Sunflowers, when young, are soft, contain no woody tissue, and are easily cut with the scythe; by fall, however, they have formed tough, woody stems like those of trees.

Cells of the potato tuber, filled with large starch grains.

Around the outside of young stems and roots, and even of leaves, is a protecting layer. On the trunks and roots of trees this is called bark, but on leaves, on the first year's growth of tree stems, and on the stems of such plants as

alfalfa or pigweed, it is called epidermis. The epidermis is much thinner than bark, but it serves the same purpose — that of keeping the plant from drying out, and of making it more difficult for enemies and diseases to injure the plant.

Plant Cells. All these parts of plants are made up of tiny cells. Each of the cells has a wall, and while it is young, and working or growing, it contains a living substance called protoplasm, together with some water and plant foods. As the cells get older they change in many ways. Thus, the cells of the framework become very much thicker-walled, the walls become much harder, and at the same time the cells grow very long and slender and lose their protoplasm. Cells of this kind form the hard strings which one sometimes finds in beets and parsnips, and which make the stems of alfalfa and sweet clover hard and tough and unfit for hay if they are cut too late. Some of the cells never thicken their walls very much. These are the ones which continue to manufacture food, or in which food is stored. The potato is a good example of a mass of such soft cells. Almost all seeds of plants are made up very largely of such soft-walled cells stored full of food.

QUESTIONS

1. What are the principal parts of a plant? How does the length of life of these parts differ in different plants? Give examples.

2. What are plant cells? What do they contain?

3. How do the cells of a potato differ from those of an alfalfa stem? from those of an oak tree?

CHAPTER II

ROOTS

Most of us are surprised when we learn that the roots produced in a season by a full-grown wheat plant would, if placed end to end, measure a total length of from sixteen hundred to two thousand feet—about a third of a mile. A pumpkin vine produces fifteen miles of roots in a season. Roots penetrate the soil, not only in all directions, but to different depths. Some of the roots lie close to the surface, even within two or three inches of it, while some of them go down to great depths. While many of the wheat and corn roots lie in the upper soil, in a field with deep soil some of their roots will grow down five or six feet. These plants are comparatively shallow-rooted. Pine trees are shallow-rooted, while walnuts have long, deep taproots. Alfalfa is an example of a deep-rooted plant. Its taproots sometimes grow to a depth of twelve or fifteen feet, and perhaps even deeper. The roots of bindweed go down from six to ten feet, and spread in every direction through the soil.

Sweet clover plants, showing the deeply growing taproots which go far down into the subsoil to obtain moisture.

Generally roots grow downward, while stems grow up-

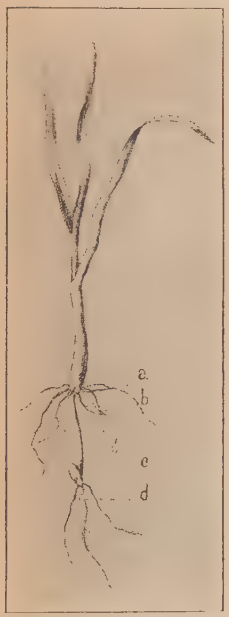
ward. Some roots, however, grow horizontally. These usually become propagating roots, and send up stems from buds which appear along their length. This is what the Canadian thistle, the field bindweed, and the western ragweed do. Weeds of this kind are hard to kill. Cultivation simply breaks the roots into pieces and scatters them. From these broken pieces buds may start and form new plants.

Brace roots of corn grow from the lower joints of the stem down into the ground, and there send out many fibrous branch roots. The plant is thus both anchored and supplied with soil water by these roots.

The Work of Roots. Large plants, such as trees, which branch widely, generally send out roots which spread as far from the trunk underground as the branches spread in the air. The roots of all plants serve to anchor the plants firmly in the soil and to brace them; to gather material for food from the soil; and sometimes to furnish places in which to store food. As the corn plant grows it sends out great numbers of brace roots from the lower joints. Radishes, beets, turnips, carrots, and sweet potatoes are examples of plants the roots of which are used as storehouses of food.

How Roots Grow. While the plant is living and growing, its roots are constantly getting longer, branch roots are being sent out, and new portions of the soil are constantly being reached in the search for more food. If the

tip of a root is broken off, it will not increase in length, but will have to send out branch roots. Branch roots may be sent out from almost any part of the side of the root. These branch roots increase in length just as the main root does. Roots increase in thickness by increase in the number of cells and by enlargement of these cells.



A young wheat plant, showing the development of the root system: *a*, stem; *b*, permanent roots; *c*, wheat kernel; *d*, temporary roots.

Roots grow away from light and toward water. Sometimes trees growing near wells and drains fill and choke them with their roots, which have grown out in search of water.

Food for Root Growth. Food for the growth of roots, that is, for the making of new cells, and for increase in the size of the cells, is secured partly from the soil, but chiefly from the upper parts of the plant. The water and the mineral matter taken in by the roots are sent up into the green stem or the green leaves, where they are used in making sugar and other plant materials, and are then sent downward as sap. This sap is carried on out to the roots to feed their tiny cells, and to enable them to grow and to make new cells.

Canadian thistle spreads by means of horizontal propagating roots, from which new plants come up.

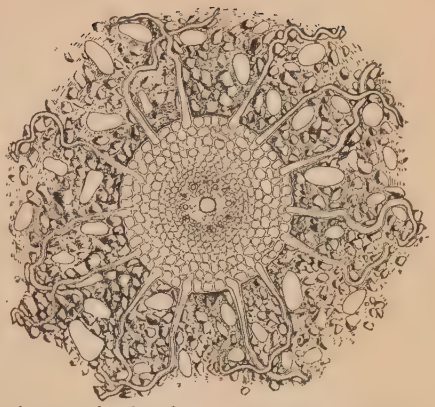
Root Hairs. Water and mineral matter can not be taken

in through all parts of the surface of the roots. Even the smallest rootlets do not themselves actually absorb most of the water. Special cells take in the water and dissolved minerals. These cells are called root hairs. Root hairs are merely very much lengthened, thin-walled cells. One end of such a cell is a part of the root, but most of the long cell sticks out from the root, and, as it grows, pushes its

Roots of corn with root hairs (magnified). The root hairs do not quite cover the tip of the root. Notice how the root grows in a spiral. This is the way in which all roots grow if they are not hindered.

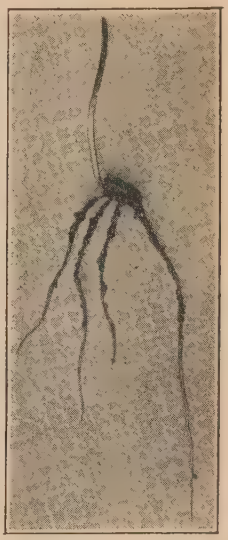
way in among the tiny particles of soil and thus comes into close touch with them. Some of these root hairs may be one-half or three-fourths of an inch long. Usually, however, they are much shorter. Because they do push out among the tiny soil particles and come into such close contact with the water surrounding the particles, and because they have such thin walls, they are well able to absorb the water. Root hairs grow only on the youngest parts of roots, close to the root tips. It is estimated that there are about 25,000 root hairs to every square inch of

root surface. As soon as a portion of the root gets older and larger the root hairs die, and the outside of the root gets too thick and hard to absorb water. It is very important that plants have a large number of small roots with many branches, since these fine roots are the ones that have root hairs. Many people think that breaking off the fine roots of plants in transplanting them, or tearing off the fine roots of corn in cultivating it, will do no harm; but we should always remember that anything which destroys these fine roots helps to rob the plant of its proper food supply. In transplanting a tree, it is well to prune back the big, heavy roots. This will cause many fine fibrous roots to grow out, upon which root hairs are borne.



A cross section through a root, showing how the root hairs penetrate the soil. The dark lumps represent the soil particles; the wavy lines represent the soil water; the light spots represent the air spaces.

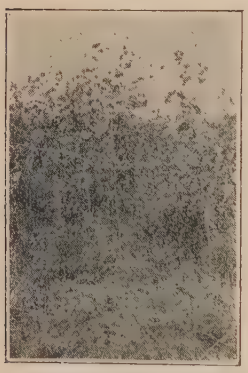
What Roots Get from the Soil. The great mass of roots which each plant has, is necessary in order that the plant may get its food from the soil. Roots take from the soil great quantities of water, and considerable



A seedling of corn, showing particles of soil adhering to the root hairs, which can not be seen.

amounts of mineral matter, such as lime, potash, and phosphorus. Both water and mineral matter are necessary to the growth of plants.

The Amount of Water Used by Plants. It requires great quantities of water to produce farm crops. A potato crop is 79 per cent water; standing green corn is 80 per cent water; cowpeas are 84 per cent water; sugar beets are 87 per cent water; a cabbage is 91 per cent water; and lettuce is 96 per cent water. Even the amount of water contained in a plant at any one time, however, is a very small part of the total amount required to build the plant. A corn plant, for instance, has been known to pass nine pounds of water through its body into the air in eight and one-half hours. In extremely windy, dry weather, it may give off fifteen pounds. Not all plants need the same amount of water, but all plants take up a weight of water equal to several times their own weight. The amount of water required to make a pound of dry matter in the corn plant is 272 pounds; in sorghum or kafir, 306 pounds; in wheat, 507 pounds; in alfalfa, 1068 pounds.



Sunflowers wasting the ground water that agricultural plants should have. They use more water than is used by corn or potatoes.

Plants Can Not Use All the Soil Water. Even in the severest drouths, there is left in the soil from five to ten per cent of the water, which the roots of plants are unable to withdraw. The amount of this unavailable water varies in different soils, being greater in a fine loam than in a coarse sandy soil. Different plants take different amounts of water from the soil. Lettuce leaves eight

or ten per cent of water in the soil when it wilts. Corn leaves in the soil only six per cent of water that it can not withdraw, while such weeds as morning-glories can use the soil water down to four per cent.

Root system of kafir, showing how the upper layers of the soil are filled with the fine fibrous roots. These very numerous roots of the kafir and other sorghums enable them to gather water from the soil better than most agricultural plants.

Weeds Waste Water. It is well to realize that weeds take a great deal of moisture from the soil every day that they live. In fact, more water is lost through weeds than from any other cause. Weeds waste the water that agricultural plants should get. The Russian thistle requires about as much water as dwarf milo. Pigweeds use about as much water as corn to make a pound of dry matter. We can grow sorghum or millet almost as easily as weeds, and they require no more moisture. Therefore, if we are to try to save the water which has been stored for the use of crops, we must destroy the weeds.

Storing Water for Plants. Since so much water is needed, one of the ways in which the farmer may help

his field crops to grow is to try to store as much water as possible in the soil. This may be done by plowing deeply, and by keeping the land level, so that the water which falls may be held in the soil and may not run off the surface.

Because plants take so much moisture from the soil, it is no wonder that a field which has borne a heavy crop has little soil water left in the upper layers of the soil.

How Plants Use Water. The first use of water to plants is to dissolve the mineral matter of the soil, which is then carried into the plant. Inside the plant, water carries the raw material and the foods manufactured by the plant to the places where they are needed. Some of the water is combined with the carbon dioxide taken from the air, to form starch. The minerals are used by the plant to build up its cells. Some of them go to one part of the plant, some to another. When we burn a plant we get a certain amount of ashes, usually not more than from two to four per cent of the total weight. These ashes represent the mineral matter taken by the plant from the soil. Although the amounts are small, some of the minerals are absolutely necessary to the life of the plant. The most important minerals obtained from the soil are lime, phosphorus, potash, magnesia, sulphur, and iron.

QUESTIONS

1. How far and how deep may the roots of crops grow? Of what advantage to plants is this spread of roots?

2. Name all the different kinds of plant roots and tell briefly how they differ from each other. What kinds of roots have special uses? Give examples of plants having such roots.

3. How do roots get material for growth? What materials do they take from the soil? What uses are made of this material? Where is it used?

4. How do roots take materials from the soil? Why is so much water taken? What finally becomes of this water?

5. How do plants differ as to the amount of water they use? Are plants able to take all the water from the soil? How is the water which plants use stored in the soil?

6. What are the three principal uses of water in a plant?

7. What soil minerals are absolutely necessary to plants? How may we recover most of this material? How do plants secure it?

CHAPTER III

STEMS AND LEAVES

The stems ot plants lift the leaves up into the air, in order to expose them to light. Stems also carry raw sap, that is, water and mineral matter, upward from the roots to the leaves. After the leaves have combined the water and the mineral matter with the carbon dioxide of the air, the manufactured food, or true sap, is sent downward through other parts of the stem, to be used by all parts of the plant. Stems of some plants serve also as places for the storage of food. The food may be stored in the stem only temporarily or for a long time. Stems may serve also to propagate the plant, either by forming runners above the ground, called stolons, as in the case of the strawberry and buffalo grass; or horizontal stems below the ground, called rootstocks, as in the case of Johnson grass.

Propagating stems (stolons) of buffalo grass, which take root at the joints and form new plants.

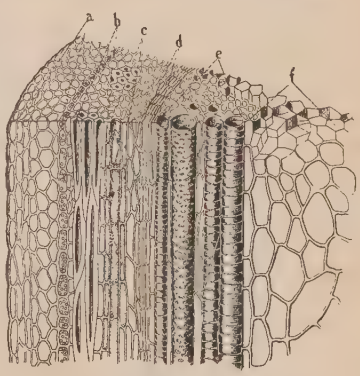
Stem Structure. Stems are able to perform these functions because of their peculiar structure. A cross section of any stem will show that it is made up of four principal parts: the pith, the woody portion, the cortex, and the bark.

The woody portion of the stem is composed of tough,

hard cells, which make the stems stiff and elastic and fit them for supporting the leaves and branches. The woody part of the trunk is divided into two parts, the heartwood and the sapwood. The sapwood alone carries the water up from the roots. The heartwood serves only to strengthen the trunk. Generally, the heartwood is colored, while the sapwood is not. In what we call "soft-wooded" trees, the amount of sapwood is generally much greater than that of the heartwood. In the cottonwood, the trunk is half heartwood and half sapwood. In the oak, the heartwood makes up about two-thirds of the thickness of the stem. In the catalpa, all but two or three years' growth is heartwood.

Underground propagating stems (rootstocks) of Johnson grass, from the joints of which new plants grow up.

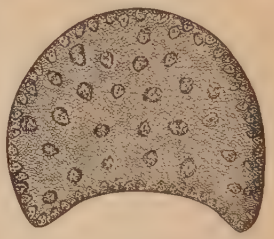
Outside the woody portion of the stem is the cortex. We often speak of it as bark, but the word "bark" should be used to describe only the hard, dry, protecting layer on the outside of the cortex. The cortex is made up of young, growing cells, and of long, tubular conduction cells, or ducts, which carry the manufactured food down from the leaves to the stems and the roots. There are also many cells stored full of food, and



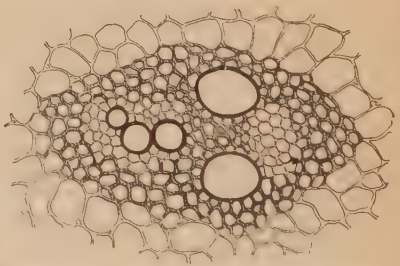
Part of the inside of the stem of a plant, highly magnified to show the different kinds of cells: *a*, cortex; *b*, fibrous cells; *c*, cells that conduct plant food; *d*, cambium layer; *e*, cells that conduct water upward; *f*, pith.

some groups of tough fiber cells, called the hard bast, which help to strengthen the stem.

How Stems Thicken. Just between the sapwood and the cortex of a tree is a layer of small, fragile cells, called the cambium layer, which can not be seen without a microscope. This layer of cells does nothing but use the food brought in through the cortex from the leaves, to make new cells. These new cells are made very rapidly during the spring and the early summer; those which are made on the outside, toward the cortex, make new cortex cells, especially sap-conducting cells, while those which are made on the inside, toward the sapwood, form new cells of the sapwood. Therefore, the cambium layer is the real growing portion of the stem. It is the cambium layer which causes the stem to increase in thickness. In the spring the cambium layer receives plenty of food and water, and consequently makes large sapwood cells. Later in the season, when the food and water supply grows less, the cambium layer makes smaller and smaller cells until fall, when it stops growing.



Cross section of corn stem, showing the groups, or bundles, of conduction cells scattered through the pith of the stem.



Single group, or bundle, of conduction cells from the stem of corn (highly magnified).

Such plants as corn, wheat, kafir, grasses, and palm trees, do not have stems like those described above. They have no solid woody portion, no cambium layer, and no cortex. Instead, the whole stem is composed of pith, scattered through which are great numbers of groups of

hard, woody cells and fibers. These groups, or bundles of cells, as they are called, carry the water up the stem. Bamboos, and most kinds of wheat and other grasses, have hollow stems. This kind of stem is stronger for its weight than a solid stem.

Injuries to Stems. If a wire be wrapped tightly about the trunk of an apple tree, the tree will finally enlarge at that point and the wire will cut almost entirely through the bark on the outside of the tree. The reason for this is that the food, which keeps on coming down the stem, is checked by the wire. That part of the tree above the wire, since it gets more food, grows much larger than the part below. This cutting off of the food supply that should go to the roots will finally kill the tree. Trees are also frequently stunted or killed when careless people break off large pieces of bark. Breaking off the bark always exposes cambium cells, which then die, leaving the wood to decay.

The Storage of Food in Stems. The manufactured food on being sent downward through the stem may be stored instead of being used immediately. It may be stored in the cells of the cortex, or of the wood or pith. It may be stored for only a short time during the growing season, and later may be used for the production of seeds. Corn, oats, and kafir use most of their stored food in this way. If these crops are cut for fodder, they must, in order that their stems may be of greatest value, be harvested just before the seeds ripen, when most of the stored food will be caught in the stem. For the same reason we cut alfalfa and other hay crops before the plants are fully ripe. Before the leaves drop from the trees in the fall, they send into the trunk the food that they contain. It is this stored food that enables trees to start their growth

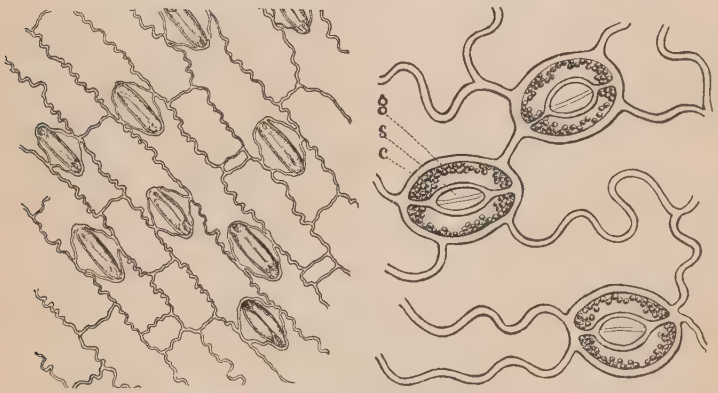
in the spring. Trees cut for posts in August, before the leaves fall, decay less rapidly than those cut in the winter. The reason is that there is less food stored in the stem to attract the germs and soil fungi* that feed on stems and thus cause their decay.

Underground stem, or rootstock, of canna, showing the buds that grow from the joints and that produce new stalks above the ground. Notice the great abundance of the large roots that grow out from the rootstock.

Underground Stems. Some plants have peculiar stems which grow underneath the ground. Many of the wild grasses have stems of this kind, which may be found if one will dig them up in the early spring, when they are being sent out from the main plant to form new bunches of grass. These underground stems serve a double purpose: they are storehouses for food; and they form a means of spreading the plant. The underground stems of cannas are dug up

* Fungi are plants that can not make their own food, and hence have to use the food made by other plants. Unlike ordinary plants, they lack green coloring matter. Molds, mildews, and mushrooms are common fungi.

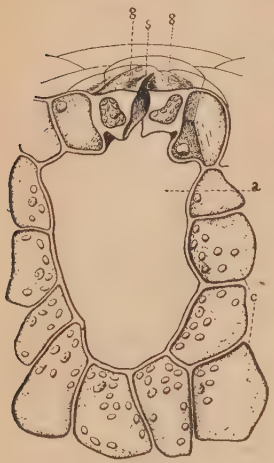
in the fall, are stored through the winter, and in the spring are broken into pieces suitable for planting. In the same way we use the underground stems of rhubarb to start new rhubarb plants. It is the large amount of food stored in these underground stems which causes the leaves of rhubarb to grow so rapidly in the spring. The potato is really an underground stem. Its eyes correspond to the buds of ordinary stems. Those weeds which have underground stems spread rapidly, and are very hard to destroy. Johnson grass and quack grass are examples of such weeds.



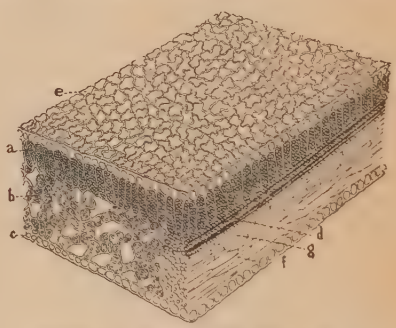
Epidermis, or skin, of corn and of lily, showing the breathing pores, or stomata: *g*, guard cell; *s*, opening of stoma; *c*, chloroplasts in the guard cell.

The great quantities of water taken up by the roots of plants are forced upward through the stems and out into the leaves through the veins. The important work which the leaf has to do is, first, to get rid of the excess of water; and, secondly, to take the mineral matter, some of the water, and some carbon dioxide from the air, and combine them to make true plant food. In order to understand well how leaves do this, we must know something about their structure.

The Structure of Leaves. The leaves of green plants are covered on the outside by a thin layer of skin, or epidermis. This tissue is usually made of cells specially constructed to prevent the evaporation of water and the drying out of the interior. But in order that the plant may get rid of the



Single stoma cut in two, showing the two guard cells, *gg;* opening of stoma, *s;* air space beneath stoma, *a;* green leaf cells, *c*. When the air outside is moist the guard cells take up water, swell, and press apart, leaving a pore, or opening, through which the water vapor from the inside of the leaf comes out. When the outside air is dry, the guard cells lose water, become flabby, and lie close together, so that there is no opening, and the moisture is retained in the leaf.



Cross section of leaf of common garden flag, or iris: *e*, upper epidermis; *a*, palisade cells; *c*, lower epidermis; *d*, water-conducting cells of leaf vein; *f*, fibrous cells of vein; *g*, food-conducting cells of vein. On the outside is the skin or epidermis. Just beneath the epidermis are many long cells which stand at right angles to it. These are called the palisade cells. They contain most of the green chloroplasts. The other cells in the center of the leaf, as a rule, contain few or no chloroplasts.

excess water, the epidermis has a great many tiny openings called stomata, through which water may pass outward in the form of vapor, and air may pass either inward or outward. The stomata are provided with special cells, so that the openings may be made comparatively large or may be almost entirely closed.

A stoma is about one thirty-fourth as large as the opening which may be made with the finest cambric needle. In order that the stomata may do their work properly there must be a great many of them. The

number of stomata varies in different plants from about 24,000 to about 180,000 to the square inch. A single sunflower leaf has as many as thirteen million. Although the stomata are very small, their great number enables them to get rid of the excess water effectually. As a rule, stomata are found in greatest number on the lower surfaces of leaves. This circumstance protects against the loss of too much water, since the lower sides of most leaves are less exposed to the sun and wind than are their upper surfaces.

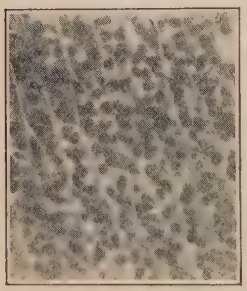
Inside the epidermis, and between the veins of the leaf, are great numbers of very thin-walled cells. These cells appear to be green because they contain great numbers of tiny green grains. These grains are called chloroplasts, and contain a green material called chlorophyll. It is this chlorophyll which gives all green plants their color. The sickly yellow appearance of some plants, especially those grown in the dark, is due to a lack of chlorophyll in their cells.

Chlorophyll is one of the most important substances in the world, since only by means of it sugar and starch can be made. Because they possess this chlorophyll, green plants alone, of all living things, are able to make these substances which are so necessary as food for both plants and animals. Were it not for the green chlorophyll of the plants, therefore, the entire animal world, including man, would finally perish of hunger.

How Plant Food is Made. It is not true, as is commonly supposed, that roots take in the finished food for plants. The roots simply gather the raw supplies out of which food is made. Most of the food is made in the leaves. The water and the mineral matter taken from the soil, and the carbon dioxide taken from the air, must be sent to the leaves, and there worked over or combined in

the green cells of the leaves, to form true plant food. This manufactured plant food may then be sent to such parts of the plant as need it. The important work of manufacturing food from the raw materials is carried on only in the presence of light, by those cells of the leaves or of the green stems which contain chlorophyll.

Most of the food manufactured by these cells appears finally in the form of sugar, starch, and woody fiber, or cellulose. The first food product made by the leaves is grape sugar. Grape sugar is soluble in the sap, and hence is easily carried to all parts of the plant. Much of the food which goes downward to help the stem and the root grow is in this form. If the leaves make grape sugar faster than it can be used for growth, it is changed to starch, and may be stored in the leaves, the stems, or the roots; or the sugar may be sent to the seeds, changed into starch, and stored there, as in corn and wheat. It is in the form of starch that most plants store their food. In sugar cane, however, from which most sugar is made, the sugar is stored in the stems. In sugar beets the grape sugar brought from the leaves is changed into cane sugar, which is stored in the large roots. We must not forget that the plant stores this food for its own use, although man has learned to take advantage of this stored food and use it himself. Because seeds contain so much of this food and so little hard, woody fiber, they are much more valuable as food for man or for animals than are stems, leaves, and roots.



Cells from a moss leaf (highly magnified). The network of lines represents the cell walls. In each of these cells can be seen a considerable number of chloroplasts. Each of these chloroplasts contains the green substance called chlorophyll, by means of which, in the presence of sunlight, the leaves are able to make starch.

In discussing animal feeds, we

usually speak of feeds which are composed of seeds or parts of seeds, as concentrates, meaning that they contain a large proportion of digestible material. The stems and leaves are called roughage, because they are coarse and fibrous, and contain a smaller amount of digestible material. We must not forget that roughage must be cut while the plant is green and contains much stored food, and before an excessive amount of woody tissue has developed. At this time the leaves of the plants are full of food, and form a very valuable part of the roughage.

The Factories of the Plant. In the green cells the chlorophyll is held in millions of little green bodies called chloroplasts. These tiny green chloroplasts are the food factories of the plant. They catch the sun's rays, and somehow by their aid, in a way we do not quite understand, they break up carbon dioxide into its elements, carbon and oxygen. This carbon dioxide is a very small part of the atmosphere, comprising not more than three or four parts in ten thousand parts of air. The air passes into and out of the leaf through the pores, or stomata, just as it passes into and out of a house through the open windows. The carbon dioxide, being perfectly mixed with the rest of the air, passes into the leaves. When it comes into contact with the green chlorophyll in the chloroplasts, it is broken up by means of the light rays, as was said, into its component parts, carbon and oxygen. Likewise, the water that comes up from the roots is broken up in the same way into the elements, hydrogen and oxygen, of which it is composed. These elements, carbon, hydrogen, and oxygen, are then combined to form grape sugar (glucose), which consists of six parts of carbon, twelve parts of hydrogen, and six parts of oxygen. Leaves need light to do their work, and they are so arranged on the

plant as to expose the largest possible number to the light. A few plants and young trees grow well in the shade, but most green plants must have an abundance of sunlight.

Buds. Plants which live from year to year and which lose all their leaves in the fall must have some way of renewing the leaves, else they would be unable to continue growth. Before the leaves are lost, the plant forms a bud just above the base of each leaf-stem. These buds are really growing points; in other words, they are places where there is always young, growing tissue, like that at the tip of the root, or like the cambium layer of the stem.

Buds are of two kinds. They may become new leaf-bearing stems, or they may produce flowers. In case the bud produces a leaf-bearing stem or branch, this in turn will bear new buds, which in their turn will grow out into branches the next season, and so the plant grows larger. Flower buds do not grow more than one season. Their life is ended when the fruit ripens.

QUESTIONS

1. During what part of the year do trees produce their new buds? Name the different kinds of buds and tell what each kind does.

2. What are the parts of a stem? What is the work or use of each part? How do the stems of corn and kafir differ from the stems of trees?

3. How do stems grow thicker? If a wire be wrapped tightly about the trunk of a tree, what effect will it have on the trunk? on the roots? Why?

4. In what forms do plants store food? What plants store food in stems? How and for what do plants use this stored food?

5. How must forage plants be harvested in order to save the most food in the plant? When should trees be cut for posts? Why?

6. Name some plants which have underground stems. What are the various uses which plants make of underground stems?

7. Name all the parts of the leaf which assist in the manufacture of plant food, and tell what each part does. What are the raw materials used in making plant food? Into what foods are these made?

8. What gives leaves their green color? Where and in what form is this material kept in the leaf?

9. What materials pass into leaves? What materials pass out from leaves? What are the reasons for these processes? Describe the mechanism which makes this passage inward and outward possible.

CHAPTER IV

FLOWERS AND FRUITS

The buds which produce new stems, or branches bearing leaves, renew the growth of the plant year by year. The buds of some plants may even fall off and make new plants; but among green plants, the buds which are chiefly responsible for the forming of new plants are the flower buds. All seed-bearing plants have flowers of some kind. Some of them are very inconspicuous and much modified, but there are certain important parts which can always be found. These parts are the ones which finally produce the seeds.

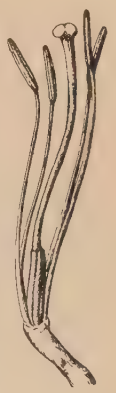
The flower of the wild evening primrose, native to the rocky hills. In the flower, inside the four large yellow petals, is a ring of eight stamens, and in the center is the pistil, of which there is visible the tall style, which is seen bending to the right, with four stigmas at its top.

The flower of the water lily. All the floral leaves are alike, and are very numerous. Just inside the wide floral leaves are seen the tops of many stamens. In the very center is the pistil, which can not be plainly seen.

The Parts of a Flower. The flower of the apple or the

peach, of the wild rose or the evening primrose, is a complete flower; that is to say, all the important parts of a flower are present. Around the outer part of these flowers is a set of green, leaf-like structures. These green leaves are called the sepals, and all the sepals put together make what is known as the calyx. The colored leaves on the outside of the flower are called petals, and all the petals put together make up what is known as the corolla. Just inside the corolla are some slender, hair-like parts, with usually red, yellow, or brownish knobs, or projections, on their ends. These are the stamens. The knobs are called anthers, and when they have ripened and opened, they give off a dust-like material called pollen. In the center of the flower stands another slender part called the pistil. The pistil has a peculiar end called the stigma. By looking at it with a hand lens, we may see that it generally has a roughened, and often sticky, surface, to which the pollen grains, upon falling there, will adhere. The bottom of the pistil is called the ovary. If this part of the pistil be opened, it will be found to contain tiny green round bodies, called

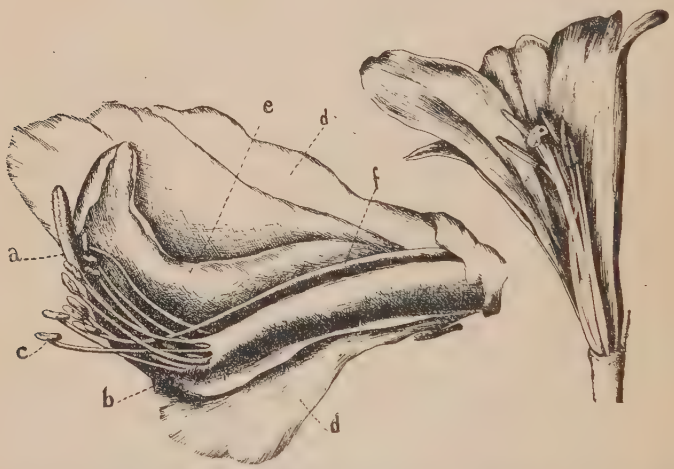
The flower of the sweet pea, showing calyx and corolla. The corolla in this flower has a large upper petal called the standard, two side petals called the wings, and two lower petals joined together, called the keel, which surrounds stamens and pistil. All legume flowers are very much like this.



The pistil and several of the stamens of the Easter lily. The stamens, with the anthers at their tops, are plainly shown. In the center is the pistil with its ovary at the base, its long style, and the swollen part at the top, called the stigma, upon which the pollen falls.

ovules, which grow into seeds after the flower has been pollinated. In peas and beans the ovary grows into a pod. Sometimes the ovary becomes very large and fleshy. Pumpkins and watermelons are ovaries of this sort.

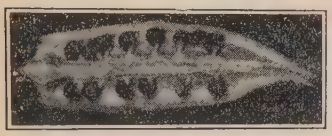
How Flowers Differ. Flowers that are pollinated by insects, ordinarily have bright colors, which, as a rule,



Left-hand figure, the flower of the sweet pea opened, with the standard and one each of the wing and keel petals removed, showing the stamens and the pistil. Nine stamens, *b*, are joined together in a ring around the pistil, which is concealed except for the stigma, *a*. There is also a single stamen, *f*, not in the ring. The anthers, *c*, which contain the pollen, are seen. The keel petal, *e*, and the upper and lower parts of the wing petal, *dd*, are shown. Right-hand flower, the flower of the Easter lily opened. In the center is the pistil, surrounded by the stamens. On the outside, some of the petals and sepals are seen.

wind-pollinated plants lack. The flowers of catalpa, peach, and red clover, are bright-colored, but the tassels of corn, and the flowers of wheat, of the elm, and of the oak, are not. Flowers differ also with regard to stamens and pistils. In the peach and the apple, stamens and pistils are found in the same flower. The same is true of the flowers of wheat, rye, and oats, but the flower of corn is quite

different. A complete stalk of corn has at least two clusters of flowers. The tassel is a cluster of flowers bearing only stamens with their pollen. The ear is composed of a multitude of flowers which contain pistils but no stamens. The silks, which are borne one from the tip of each kernel, and which become exposed at the ends of the husks, are the stigmas of these pistils. The ovary, which is found at the base of each silk, finally grows into the kernel of corn. In the squash or the pumpkin we find some flowers with stamens and other flowers with pistils, but no flowers with both. The cottonwood, some varieties of strawberries, and some mulberries bear on one plant flowers with pistils only, and on another plant flowers with stamens only. Some flowers, like those of the dandelion, wheat, oats, and barley, habitually self-fertilize; that is, the pollen falls on the stigmas of the flower from which it came. Other plants, like rye, corn, cotton, and most of the common trees, especially those in which the



Ovary of okra plant, opened to show the rows of ovules.

Staminate flower of corn (highly magnified), showing three stamens.

A tassel of corn in bloom showing the stamens hanging down from the staminate flowers. There are three stamens in each flower, and two flowers are found growing together in what is called a spikelet.

Highly magnified portion of a young ear of corn with husks removed, showing the way the silks or stigmas of the pistils are attached to the ovaries—the kernels. Picture on the left before fertilization. That on the right after fertilization, showing the growing kernels with many of the silks fallen off.

The flower of the common red geranium, with calyx and corolla removed, shortly after the flowers of the plant are in full bloom. The figure to the left shows construction of the flower, as it is in the bud. The six stamens, with their large anthers, are in view, but the pistil has not yet become the style but not yet grown up. The central figure is from a flower which has fully opened. The anthers are shedding their pollen, and two of the anthers have fallen off their filaments. (All the pistil has not yet grown up, and may not be pollinated). The figure to the right is from a flower in a still later stage. The anthers have all fallen off their filaments. The style has now grown up, and the five stamens have spread out, ready to receive the pollen brought by some insect from another flower.

wind carries the pollen, such as elm, ash, walnut, oak, and hickory, are cross-pollinated. Some kinds of pears and grapes, especially, produce few or no fruits if self-fertilized. Other varieties have to be planted near them to serve as pollinizers.

Pollination. In order that a flower may produce seeds, it is necessary for some of the pollen from the anthers to be carried to the pistil and to stick fast to the stigma. This process of transferring pollen from the anther to the stigma is known as pollination. When corn is pollinated, some of the pollen is transferred from the tassel to the silk. The silks may be pollinated anywhere along their length. Corn generally sends out the tassels before the silks of the ears on the same plant appear. This usually insures more or less crossing, or cross-pollination, as it is called. Plants the flowers of which are fertilized with their own pollen are said to be close-pollinated. If the pollen does not

Young ears of corn, with husks removed, showing the rows of pistils—the kernels—bearing the silks, which are the stigmas.

Pollen grain germinating, showing the pollen tube, which grows into the stigma of the flower.

reach the silk, pollination does not take place, and grains of corn do not form. When corn sends out its tassels in very hot weather, it sometimes happens that all the tassels are killed. In such cases, there is no pollen to fertilize the silks, and consequently the crop is a failure.

Fertilization. When the pollen grains fall on the stigma, they germinate, and a tiny germ tube sprouts out of each one and grows into the stigma, down through the long part of the pistil called the style, and into the ovary. The pollen tubes often have to grow several inches in this way before they reach the ovary. They are enabled to do this by the fact that they absorb food from the pistil as they grow down. Once inside the ovary, the pollen tubes grow toward and into the ovules, fertilizing the tiny egg cell that is in each. The fertilized egg cell immediately begins to grow into a little plant in the midst of the ovule, which in turn grows large and becomes a seed. Only one pollen grain is necessary to fertilize a single ovule. In corn there are about seven thousand pollen grains for every ovule, but, of course, much pollen is lost in the wind.

QUESTIONS

1. Name the parts of a flower. Name the divisions of the important parts and tell what each division does.

2. Why is so much pollen produced? Name the different ways by which it may be transferred to the pistil. Name at least one plant illustrating each method of transfer.

3. How do flowers differ in respect to their stamens and pistils? Give more than one difference.

4. What is meant by self-pollination? by cross-pollination? Give examples.

5. What is meant by fertilization? Tell fully how it is accomplished.

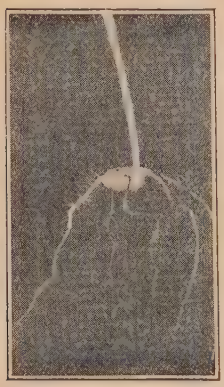
CHAPTER V

HOW PLANTS MULTIPLY

The Germination of Seeds. A seed of any plant is usually made up of two parts: first, a tiny plant or germ; second, enough food to support the germ until it has grown large enough to make its own food. Some plants, such as the bean and the pea, store all the food within the germ. In others, such as wheat and corn, most of the food is stored around the germ. While seeds are ripening, a great deal of water is usually drawn from the germ and from the stored food, leaving the seed hard and dry. Even after the seed has completely ripened, the drying process should go on for some time, in order that the seed may keep well until planting time. The tiny plantlet lies dormant for a time after it has been completely formed, and after the seed has ripened and dried.

In order that a new plant may be produced from the seed, there must be certain conditions which will start the germ growing and enable it to use the stored food. These conditions are: first, the proper amount of moisture; second, air; third, proper temperature. Various kinds of seeds differ in their needs. The seed absorbs water, and if the temperature is right, cells start working. The stored food is changed into digestible form, and is dissolved in the water which has been absorbed. It then passes into the cells of the young plant, or germ, to be used. The oxygen of the air is used in furnishing the energy which changes the food into plant tissue and which thus brings

about growth. None of these things will take place without a proper temperature. The same kind of seed will germinate at different temperatures, but there is always a certain temperature which is most favorable to prompt and rapid germination. This temperature varies greatly for different plants. Since oats, peas, and radish seed will germinate well at comparatively low temperatures, they may be planted early in the spring. Corn and alfalfa seed require higher temperatures, and can not be planted so early as oats and peas. The sorghums require an even higher temperature for germination, so that they must be planted later in the spring, or even early in the summer, in order to secure prompt and complete germination. Difference in the temperature suitable for germination is one of the reasons for planting garden and field seeds at different times during the planting season.



Corn germinating. The food which starts the young plant comes from the endosperm. Notice that the taproot of the corn comes out through the tip of the germ, and has already developed branch roots, upon which the root hairs will grow. The other four roots are secondary roots.

The Seed Bed. When a farmer or gardener prepares a seed bed, he should have in mind the fact that he is fitting the seed bed to furnish the best possible conditions for the germination of the seeds and the growth of the plants. Every good seed bed is made of earth which is not packed hard, but is loose enough to contain some air. It must not, however, be cloddy, or so loose as to dry out rapidly. It must have had an opportunity to become warm and must contain the right amount of water. When seeds are properly planted in such a seed bed, they come into contact with plenty of water and air, and as the soil is

warm enough, they germinate rapidly. Before all the stored food has been used up, the plant should be taking water and dissolved minerals from the soil and its leaves should be gathering material from the air and manufacturing food.

How the Young Plant Grows. As soon as the seed gets sufficient water, air, and heat for germination, the stored food begins to be carried to the growing tip of the root and of the stem of the germ. The germ begins to enlarge. Soon the root pushes out into the soil, and the stem begins to grow longer, and finally reaches the top of the ground. Small seeds which contain but little food must be planted nearer the surface than larger seeds; otherwise the stored food may all be used before the young plant has broken through the ground. Such seeds as alfalfa, sweet clover, grass, and turnip seed, must not be covered very deep, while the seeds of wheat, peas, beans, corn, and squash, which contain more stored food, may be planted deeper. The large, thick seed leaves of the Lima bean are carried above the ground by the growing stem, turn green in the sunlight, and thus not only

Seedling beans, showing the large seed leaves, which furnish food for the plant until the true leaves develop. In the illustration the first pair of true leaves is seen above the seed leaves.

furnish stored food to the young plant, but can make new food with their green cells, which sustains the plant until the permanent leaves appear.

Storing Seeds. When seeds have been harvested, they should be stored in a dry place until the surplus water has evaporated from them. Seeds should never be heaped together in quantities until thoroughly dried. Seeds are almost certain to be injured if stored in damp places. When so stored, they are attacked by bacteria, or by molds or other fungi, which cause them to decay. Seeds are often killed by freezing before they have become thoroughly dry. In general, seeds of agricultural plants intended for sowing should not be exposed to temperatures below freezing until

A potato plant, showing propagation by means of underground stems, which bear large tubers.

Tuberose, a bulbous plant propagating by the production of new bulbs. Large roots come out from the base of the old bulb of last year. New bulbs are produced as offsets, and serve to propagate the plant.

they are thoroughly dry. Sometimes insects injure seeds. Sometimes seeds are too old to germinate well. Some seeds will germinate several years after they are gathered, while others must be planted within a year or two. (See table in the Appendix.)

Corm of gladiolus: *a*, new corm from which this year's flower stalk came; *b*, tiny corms, or "cormels," borne as offsets of this year's corm; *c*, remnant of last year's corm. A corm is solid, while a bulb consists of scales.

Testing Seeds. In order that the farmer or gardener may be sure that he is always using good seed, he should test all seed before buying or planting it. He may easily test seeds by planting them on blotting paper between two plates, keeping them barely moist and in a warm room; or he may plant them in a box of sand or sawdust.

Spore Plants. New plants are formed from old ones in several ways. All of us know about seeds, and we know that they form new plants. Not all of us know, however, that the fine dust which comes from a puffball, or the powder that makes the under side of some toadstools black or brown, serves the same purpose as seed; that is, it may start a new plant. Such tiny bodies are called spores. The plants which bear spores never flower or bear seeds, but depend upon the spores to form new plants. Some of these spore-bearing plants are green and can make their own plant food. The green pond scums, or slimes, which grow in water, the seaweeds of the ocean, the mosses which grow in moist, shady places, and the ferns, are the best-known examples of green spore-bearing plants. None of these is of very great importance to the farmer. The other spore-bearing plants are not green, and therefore can not

make their own sugar and starch. The toadstool, the bracket fungus, and the common mold are examples of these. These plants depend for their food upon starch and sugar manufactured and stored by green plants. For this reason, toadstools and bracket fungi grow on rotten wood or decaying roots, or even sometimes infest living trees and destroy them. Black mold grows very commonly on bread. Green mildew grows on cheese, orange peels, and the like. Some plants which reproduce by means of spores, and which can not make their own starch and sugar, get this material from live plants, and are called parasites. The wheat rust, corn and wheat smuts, the black knot of the plum, and some other plant diseases are examples of these.

A catalpa trunk attacked by bracket fungus. The feeding part of the fungus is inside the tree. The part which comes out and forms the bracket is the spore-bearing part. The spores are borne in slits on the under side of the bracket, which correspond to the gills of the mushroom.

Other Ways of Plant Propagation. Another way in which plants reproduce is by means of propagating roots, as do the bindweed and the Canadian thistle. Other plants reproduce by means of underground stems. Of this method the tuber of the potato furnishes an example. The rootstocks of the canna and those of Johnson grass are other good examples of this kind of propagation. Some plants reproduce by means of bulbs. The onion, the tuberose, and the hyacinth are examples of bulb-producing plants. Strawberries and buffalo and Bermuda grass reproduce by means of runners which are sent out and take root and grow. Black raspberries form new plants from the tips of their stems, which bend to the ground and take root. From these points new stems grow up.

Conditions of Growth. Some plants grow best where

the soil is very wet or swampy. Such plants are said to be water-loving plants. Others grow best under dry conditions, and are called desert plants. Farmers have learned that some of their crops, such as rice, for example, should grow in very wet soil, and that other crops, such as clover and alfalfa, will not grow at all under this condition. They have learned, too, that the sorghums will grow where there is comparatively little rainfall. They know that some plants, such as corn, prefer a loose, loamy soil, while wheat and buckwheat prefer a more compact soil.

Plant Culture. The successful farmer is the one who understands best how plants grow. He knows the kind of soil each crop prefers, and how to manage this soil so that the plant's roots may best absorb water and mineral matter from the soil, and its leaves may best get the sunlight to manufacture food. He has also learned to control the weeds, so that the crop is not robbed of soil water, or shaded until it becomes too weak to manufacture food. Such a farmer also knows how to select and care for his seed and to plant it in a suitable seed bed.

QUESTIONS

1. What are the parts of a seed? What is the function of each part? How are foods stored in the seed?

2. What are the conditions necessary to sprout seeds? How are these conditions provided in the seed bed?

3. How do seeds differ as to the temperature required for germination? Give examples.

4. Give complete directions for storing seeds. Give reasons for your directions.

5. Why should seed be tested before planting? Give directions for testing seed.

6. What are spores? Give some examples of spore plants. How do they differ from seed plants?

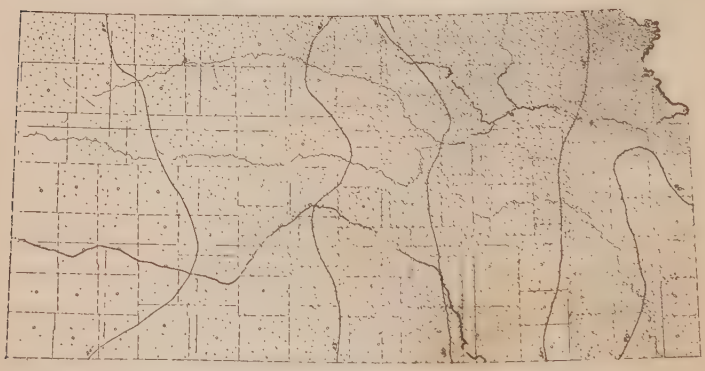
7. Make a list of all the ways in which plants multiply. Name at least one example of each kind of multiplication.

CHAPTER VI

CORN

Of the important grain crops grown in the United States corn is the only one native to America. All the others have been introduced from foreign countries. Corn is supposed to have originated in Central America. The Indians were growing it when Columbus discovered the New World.

Corn is the most important cereal crop of Kansas, and also of the United States. About one hundred million acres, or an area nearly twice the size of the state of Kansas, is planted to corn every year in the United States.

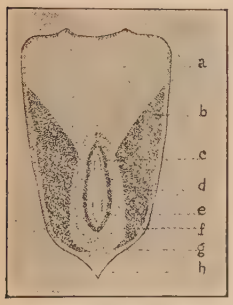


Map of Kansas showing the production of corn, average of five years, 1909-1913. One dot represents ten thousand bushels.

Kinds of Corn. Five different types of corn are of economic importance. They are dent corn, flint corn, soft (or squaw) corn, sweet corn, and pop-corn. Pod corn is sometimes grown as a curiosity, and Japan corn as an orna-

mental plant. Dent corn is by far the most important type, as it comprises most of the corn grown in Kansas as well as in the United States. There is a very large number of varieties of this type, twenty or thirty of which are grown in Kansas.

In dent corn the endosperm, the part surrounding the germ, is of two kinds, the starchy endosperm, and the horny endosperm. The starchy endosperm is mainly in the center of the kernel, while the horny endosperm lies near the surface. When the kernel dries out in ripening, the starchy endosperm shrinks more than the horny endosperm, thus causing the corn to dent.



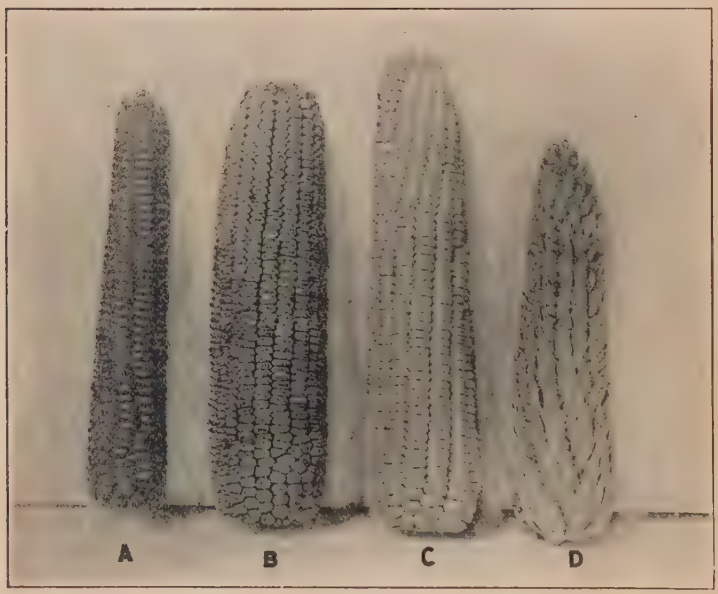
Parts of the corn kernel: *a*, starchy endosperm; *b*, horny endosperm: *c*, stem; *d*, germ; *e*, root; *f*, starchy endosperm; *g*, hull; *h*, tip cap.

Flint corn is grown chiefly in the New England states, where very early maturing varieties are necessary. Flint varieties usually do not yield so much as does dent corn, and the grain is so hard that flint corn is not so satisfactory a stock feed. The starchy endosperm in flint corn is very small, and is entirely surrounded by a thick, horny endosperm. Consequently, when the corn dries out it does not dent.

Except for being much smaller, the pop-corn kernel is very much like that of flint corn.

Soft, or squaw, corn is grown by the Indians in New Mexico and Arizona, and to some extent by farmers in other dry regions of the United States. It is very soft, and the ease with which it can be ground into meal is probably one of the principal reasons why it has been grown by the Indians, though it is thought by some to be more drouth-resistant than other kinds.

Sweet corn differs from other kinds of corn in the large amount of sugar contained in the grain. As the yield is much less than that of field corn, sweet corn is never grown except for table use, or, occasionally, for early feed.



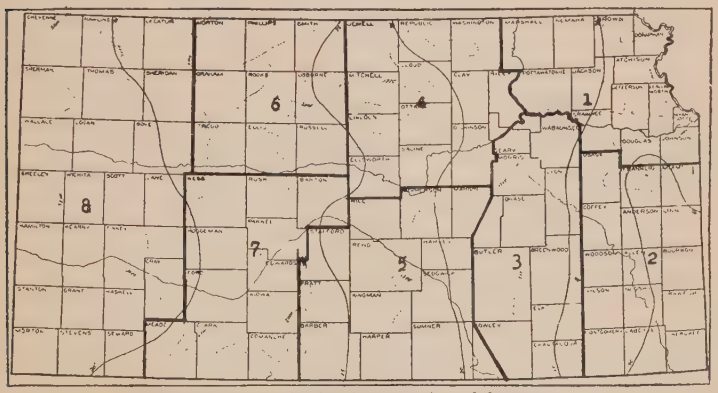
Types of corn: *A*, Flint corn; *B*, Dent corn; *C*, Soft corn; *D*, Pod corn.

Pod corn is peculiar in that each kernel is surrounded by a separate husk. Its yield is very small and it is of no economic importance.

Varieties of Dent Corn. Many varieties of dent corn are grown in the United States. Different varieties are adapted to different localities.

In northeast Kansas, for example, the rainfall is ample. In this region varieties such as Boone County White, Kansas Sunflower, Reid's Yellow Dent, and Commercial White, which produce large, vigorous stalks

and large ears, and require a rather long season to mature, give the best yield. In central and western Kansas the rainfall is less, the elevation is greater, and the seasons are shorter. If seed of one of the large varieties is planted in central or western Kansas, such a growth of stalk and foliage is produced that little available moisture remains with which to produce grain. If, on the other hand, the seed of a smaller, earlier-maturing variety, such as Pride of Saline and adapted strains of Kansas Sunflower, Iowa Silvermine, and Hogue's Yellow Dent, is planted, a fair yield of grain will be produced.



Map of Kansas, showing the corn regions of the state.

The varieties adapted to the different regions of the state, as shown in the accompanying map, are as follows:

Region 1: Boone County White; Reid's Yellow Dent; Kansas Sunflower; Commercial White.

Regions 2 and 3: Kansas Sunflower; Commercial White; Hildreth Yellow Dent on bottom land.

Region 4: Kansas Sunflower; Pride of Saline; Hogue's Yellow Dent; Reid's Yellow Dent; Iowa Silvermine; Boone County White.

Region 5: Pride of Saline; Kansas Sunflower; Iowa Silvermine.

Region 6: Pride of Saline; Hogue's Yellow Dent; Iowa Silvermine; Reid's Yellow Dent; Kansas Sunflower.

Region 7: Pride of Saline; Hogue's Yellow Dent; Kansas Sunflower; Iowa Silvermine.

Region 8: Iowa Silvermine (early strain); Freed's White Dent; Sherrod's White Dent; local strains.

Home-grown Seed. Usually the best varieties are those which have been developed in the local community where they are to be grown. Corn adapts itself to soil, temperature, and rainfall, after being grown in a region for a long time. When a corn accustomed to growing with plenty of rain is taken to a climate where the rainfall is less, it will not yield nearly so well as a variety accustomed to dry weather and hot winds. It takes at least three years, and sometimes much longer, for a variety to accustom itself to new conditions.

The agricultural college conducted experiments in eight counties in four different years to learn the difference between the yield of corn from home-grown seed and from seed of the same variety from another region of the state, when the two were grown side by side. These experiments were carried out to see just how much was lost by sending to a distant part of the state for seed corn.

In Jewell county the crop was nearly eight bushels an acre more from home-grown seed than from seed brought in from other regions of the state. In Harvey county the crop obtained from planting home-grown seed was six and one-half bushels an acre greater than that obtained from the use of introduced seed. In Linn county the difference in favor of the use of home-grown seed was about ten and three-quarters bushels an acre. In Butler

county the average of three years' tests was about twelve and one-half bushels an acre in favor of home-grown seed. In Chase county the difference was eight bushels to the acre in favor of home-grown seed; in Greenwood county, seven bushels; in Cherokee county, nearly eight bushels; in Kingman county, about five and one-half bushels.

The average of all tests showed a difference of more than nine bushels to the acre in favor of home-grown seed. Thus the yield was increased almost one-third by the use of home-grown seed, as compared with bringing seed in from another region. If the seed used in these tests had been brought from outside the state instead of from another part of Kansas, even a greater difference in favor of home-grown varieties would have been shown.

Types of ears of corn. Numbers 1 and 2 are good ears; 3 is too tapering; 4, reverse tapering; 5, too long; 6, too small in circumference; 7, too short, and large in circumference; 8 and 9 have crooked rows and kernels of irregular shape.

Selecting Seed Corn. The only safe way is to select seed on the farm on which it is to be grown, or in the same neighborhood. To avoid possible loss in a poor year,

enough should be selected for two years at least. As a dozen good-sized ears will plant an acre, enough seed for planting a large acreage can be selected in a short time. The most desirable ears should be selected in the field before frost.

Points in Selecting Seed. The principal points to consider in selecting corn for seed are maturity, size of ears, and environment. The ears should be sound, and should show by their appearance that they are not too late in maturing for the locality. If the season has been a very poor one for corn, due allowance must be made. If, on the other hand, the season has been very favorable, only those ears which will pass the most severe test, in form and development, should be accepted.

If the smallest ears are selected, there will be a tendency for the variety to become earlier and the yield less. Ears that are too large will be likely to produce immature corn the following year. Therefore, as large ears should be used as can be depended on to mature in the locality.

If corn is not selected in the field, there is no way of knowing under what conditions a good ear was produced.

A well-selected sample of corn.

The excellence may be due to unusually rich soil in the spot in which the ear grew. Perhaps the stand was rather thin, giving this ear an advantage over the others. Such

an ear, even though large and well developed, might not be better for seed than a much poorer ear grown where the soil was not fertile or where the stand was thick. It is important to select good ears which have grown on soil of the average quality, where the stand was uniform.

Storing Seed Corn. The failure of seed corn to grow well is usually due either to the immaturity of the seed or to lack of care after the corn is gathered. Immature corn does not have the vitality and strength of mature corn.

A good way to store seed corn.

Even in mature corn, the germinative power may be greatly injured through lack of proper care. Seed corn may be damaged in two ways: by freezing when it is damp; by remaining damp for a long time. Seed corn that is properly dried, and kept dry, will not be injured by the coldest weather.

One of the best ways to dry and store corn is to hang it up in strings of from ten to twelve ears, in an attic or a machine shed. There should be sufficient circulation of air to dry the corn rapidly. After it is dry it may be stored in any dry place where it will not be injured by rats or mice. Seed corn should not be stored in a cellar, over grain in a granary, or in a barn where cattle or horses are kept. In all these places it will absorb moisture from the air, and by spring may be greatly injured.

Testing Seed Corn. Even though corn is cared for in the best possible way, a germination test should be made in the spring. A preliminary test is made by taking one kernel from each of a hundred or more ears, placing the kernels about an inch deep in a box of wet sand or soil, and keeping the box in a warm place for about a week. Or, the kernels may be germinated between wet sheets of blotting paper. If ninety per cent or more of the kernels germinate, the corn may safely be used for seed. If, however, less than ninety per cent germinates, it is advisable to test each ear, throwing away those ears which do not show a germination of ninety per cent or better.

A home-made seed-corn germinator.

The Ear Germination Test. The material required for

an ear test comprises a box about three feet long, two and a half feet wide, and six inches deep; a sack of sawdust or chaff; two pieces of muslin the size of the box; and one piece of muslin a little more than twice as large. One piece of muslin should be marked off in two and a half-inch squares, which should be numbered. The ears of corn to be tested should be numbered to correspond with the squares. The sawdust or chaff should be soaked in water —warm water is to be preferred—until it is thoroughly wet. After it has drained, enough should be placed in the box to make it about half full when the sawdust or chaff is packed down. The ruled muslin is then moistened and placed on the packed sawdust or chaff. When this has been done, six kernels are taken from each ear and placed in the square having the same number as the ear. These kernels should be taken from different parts of the ear, as one side may be injured while the rest of the ear may be uninjured. A good plan is to take two kernels from opposite sides of the ear, at the tip, at the middle, and at the butt, giving the ear a quarter turn each time two kernels are removed. The kernels should be placed germ side up on the muslin.

The results of a germination test, showing kernels taken from dead, weak, and vigorous ears.

When all the squares are filled, the second piece of muslin should be moistened and laid over the corn carefully, so as not to disturb the kernels. The larger piece of muslin may then be laid over the whole and the rest of the

sawdust or chaff placed on it. This sawdust or chaff is leveled and packed down in the box, especially around the edges, to prevent drying. It need not be packed so solidly as that in the bottom of the box.

The box should be left in a warm room for several days, but not too near a stove. From six to ten days—depending on the temperature—after the corn is placed in the box the test is ready to be read.

Reading the Test. In preparing to read the test, first remove the top layer of sawdust or chaff by rolling up the top piece of muslin containing it. The second piece of muslin should then be removed, care being taken that no kernels stick to it and are misplaced.

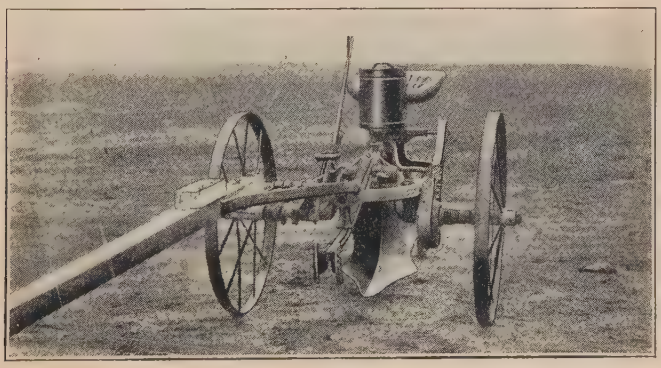
In looking the corn over, some difficulty will be found in deciding which ears to save and which to throw away. A good plan is to have three lots. In the first, place those ears all six kernels from which germinated strongly. In the second, place those ears which had one dead or weak kernel out of the six. In the third, place those ears which were entirely dead or in which two or more kernels were dead or weak. The first lot may be put away for seed. The second lot may be saved for emergency. The third lot should not be used for seed in any event, but should be thrown into the feed bin.

Decrease in Yield of Corn. The acre yield of corn in Kansas has decreased steadily for the last forty years. Corn has been grown upon the same land continuously for so long that much of the available plant food has been consumed. Corn is grown upon the same land year after year, and weeds, insects, and other pests accumulate in soil that is planted to one crop year after year. Moreover, the fertility and the water capacity of the soil are further decreased by the destruction of humus, or vegetable matter, through continuous cultivation of the ground.

The remedy is to rotate corn with other crops. A rotation prevents multiplication of insects, checks the growth of weeds, and aids in keeping up the fertility of the soil.

Crops to Precede Corn. The best crop to grow before corn is some legume. In eastern Kansas this may be clover, alfalfa, or cowpeas. In central Kansas alfalfa can be successfully grown, and except in the extreme northern part, cowpeas also. In dry seasons corn burns out badly when grown after alfalfa. In regions of limited rainfall, a crop of kafir or some other sorghum should be grown between alfalfa and corn. In the eastern third of the state, when corn is to follow a wheat or oats crop, it is advisable to sow cowpeas as a catch crop as soon as the small grain is harvested. The cowpeas will make a good growth before frost, and may be either pastured or plowed under for green manure. In either case, the corn crop that is to follow will be greatly benefited.

Methods of Planting Corn. There are two common methods of planting corn in Kansas—listing and surface-



A lister.

planting. By the first method, the corn is planted in the bottoms of deep furrows made with a lister. When the

corn is to be listed the ground often is not cultivated until time to plant the seed. In surface-planting, the corn is planted in level ground with a corn planter, after the land has been plowed and worked.

Listed corn stands drouth better, is more easily cultivated, and is not so easily blown down as is corn planted with a corn planter. But where rains are plentiful, listed corn does not germinate so well and is more easily drowned out.

The ground does not warm up so quickly in the bottom of deep furrows as on the surface of the ground. For that reason listed corn makes a slower growth than surface-planted corn, and does not produce so large a yield when the soil is fertile and there is plenty of moisture. Where moisture is likely to be deficient, listing gives better yields. It has been found that listing gives the best yields in central and western Kansas; surface-planting, in the eastern third of the state.

A seed bed in good tilth.

Preparing Ground for Listed Corn. Although many farmers do nothing with their ground until they are ready

to plant, this is not the best course to pursue. When ground is not growing a crop it should be getting ready for the next one. It does not do this when it is left throughout autumn, winter, and early spring just as when the previous crop was taken off.

One of the best ways to prepare ground is to list it in the fall, in the winter, or very early in the spring. This is done to absorb most of the rain that falls and to store it for use the following summer. When corn-planting time comes the corn may be planted in the old furrows; or, if weeds have begun to grow, the ridges may be broken out, or "split," and the corn planted in the new furrows.

If for any reason it is not feasible to list the ground in the fall, winter, or early spring, it should be disked in the spring as soon as it is dry enough to work. This will prevent the evaporation of moisture already stored in the soil, and will put the ground into better condition to absorb the water from rains.

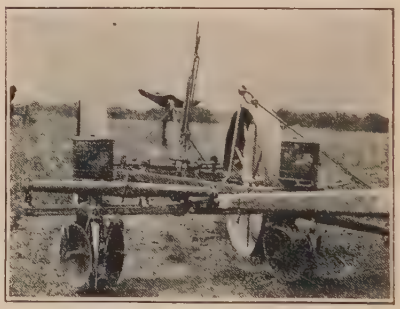
The Time of Plowing for Corn. When corn is to be surface-planted, the best time to plow is in the fall. Ground plowed at this time is exposed all winter to the frost, which pulverizes it and puts it into excellent condition for a crop. Plowed ground catches more rainfall and helps prevent the rainfall from running away. When alfalfa or clover is plowed up, there is more time for the roots to decay if the breaking is done in the fall. If the ground is infested with cutworms, white grubs, corn-ear worms, wire root-worms, or other insects, fall plowing will kill many of them.

If ground can not be plowed in the fall, it should be plowed in the winter or as early in the spring as possible. Ground plowed just before planting time is likely to be too loose for a good seed bed, and is never in so good condition as land plowed early. If the surface is baked,

or if weeds begin to grow, ground that can not be plowed early should be disked.

The Depth of Plowing. Corn requires a deep seed bed. It therefore makes the best growth when the plowing is rather deep—from seven to eight inches. It usually does not pay to plow deeper than eight inches. If the plowing is done immediately before the corn is planted, it is better to plow only four to five inches deep.

The Rate of Planting. Corn is more often planted too thick than too thin. While thick planting gives larger yields on good land and in good seasons, the opposite is true on poor land or in dry seasons. The size of the corn grown also makes considerable difference. On the same kind of land a small early corn may be planted much thicker than a large late corn.



A corn planter with disk furrow openers.

In the eastern part of the state, if the corn is checkrowed, two good stalks to the hill are sufficient on all but the best bottom land and in the more fertile portions of northeastern Kansas, where three stalks are probably better. In central Kansas, where corn is usually listed, one good stalk every twenty-two to twenty-four inches is enough. In western Kansas the stalks should be from twenty-eight to thirty-two inches apart in the listed row.

The Depth to Cover Corn. The depth to which corn should be covered varies with the time of planting, with the kind of soil, and with the moisture conditions. It

should be covered just so deep that it will not dry out before it germinates and becomes established in the soil. In the eastern part of the state the best depth is usually about one inch. This gradually increases as one goes west, until in western Kansas corn may be covered to a depth of two and a half or three inches. Corn which is planted early is not planted so deep as that planted late, since moisture is usually more plentiful, evaporation is less, and there is less danger of the corn's drying out. In western Kansas, for example, the earliest planting may be as shallow as one inch, while the corn planted late should be covered not less than three inches.

The Cultivation of Corn. The purposes of cultivating corn are to kill weeds, to prevent excessive evaporation, and to aërate the soil. Controlling the weeds is by far the most important of these purposes; for, if weeds are allowed to grow, they take moisture and plant food that should be saved for the corn.

Frequency and Depth of Cultivation. If corn is cultivated frequently enough to keep out the weeds, there is usually no need to worry about aëration of the soil and the conservation of moisture. The number of cultivations necessary to keep out weeds varies with season and locality, the usual number being from four to six. It is better to cultivate when the weeds are very small, as they are much more easily killed at that time. A cultivator with smaller shovels may also be used to advantage while the weeds are small. If surface-planted corn is planted in hills, so that it can be plowed both ways, the field can much more easily be kept clean.

It has been found that shallow cultivation, two to three inches deep, gives the best results, provided it is sufficiently deep and frequent to kill the weeds. If weeds get ahead,

because of rainy weather or for other reasons, it is better to cultivate rather deep to kill the weeds than to cultivate shallow and allow a part of them to escape.

Deep cultivation, that is, deeper than four inches, is likely to cut off the roots and injure the corn more than it benefits. This is especially the case if the cultivator is run close to the row late in the season.

QUESTIONS

1. Describe the types of corn that are of economic importance. In what parts of the United States are the three most important types grown?

2. What are the conditions of the soil and climate and the characteristics of the plant which determine what variety of corn will yield best in a given locality?

3. Why should one choose different varieties of corn for eastern and for western Kansas? Name desirable varieties for each part of the state.

4. What are the objections to using seed corn brought from a considerable distance?

5. How does the present acre yield of corn in Kansas compare with that of forty years ago? Why? How may the present yield be profitably increased?

6. What crops should follow corn? What ones precede corn? Why? How would this vary in different parts of the state?

7. Name all the advantages and disadvantages of listing corn; of surface-planting corn. Where is listing to be preferred to planting?

8. When should ground be plowed for corn? How deep? Under what circumstances and how will the depth of plowing vary? Give reasons for each answer.

9. How deep should corn be covered in planting? What conditions will cause the depth to vary? How will it vary?

10. What are the objects to be accomplished by cultivating corn? What are the conditions which will determine time, depth, and frequency of cultivation?

11. How should seed corn be selected? Why? What characteristics of the stalk would you consider in selecting seed corn? What characteristics of the ear?

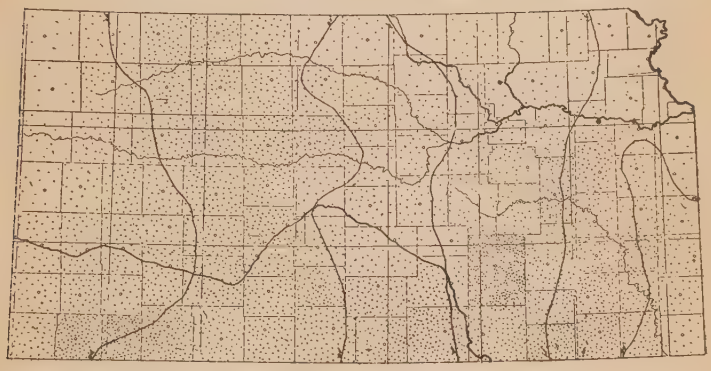
12. How should seed corn be stored? What are the reasons for such care?

13. When, why, and how should seed corn be tested?

CHAPTER VII

SORGHUMS

The word "sorghum" is a general term that includes those plants known as broom corn, kafir, milo, Jerusalem corn, kaoliang, and others, as well as those ordinarily called cane. The sorghums are natives of equatorial Africa and of India and China, and by nativity and natural selection are adapted to a warm and dry climate.



Map of Kansas, showing acreage of sorghums, average of five years, 1909–1913. One dot represents two hundred acres.

The Present Importance of Sorghums. The area devoted to sorghums in Kansas has increased tenfold in the last ten years, and is now about one-fourth the area normally sown to wheat and more than twice the area devoted to alfalfa. This increase is due principally to the fact that sorghums of the various classes are now exten-

sively used for pasture, hay, silage, and grain crops as well as for the manufacture of sirup.

Adaptability. Sorghums are adapted to practically all classes of soils found in this state, with the exception of those which are extremely alkaline and those which are very wet and poorly drained. They are grown throughout the tropical regions and over most of the temperate zones, and one or more varieties are used by almost every civilized people.

The Introduction of Sorghums into the United States. Most of the sorghums now under cultivation in this country were introduced either by the United States Department of Agriculture or by some state experiment station. The first of the sweet sorghums now grown in the United States was imported in 1853. In 1856 the United States government began to distribute free the seed of this sorghum. This variety, now called black cane, was known at that time as Chinese sugar cane.

Sorghum plants, showing root development.

The kafirs first reached this country in 1875 or 1876, being imported to the southern states. They proved of small value there, but when they were brought to the drier regions of Kansas, Oklahoma, and Texas, several years later, their true worth was discovered. The exact date on which milo reached this country is uncertain, but the plant was probably imported by the United States Office of Sugar Plant Investigations in 1884 or 1885.

In obtaining the fifteen or twenty varieties that would be considered of most importance in the United States, considerably more than one thousand lots have been grown and tested experimentally.

Description. The sorghums are grass-like in appearance, except that they are much coarser. The center stem is strongly developed, and all the common varieties are annuals; that is, live but one year. Depending upon the variety, the number of leaves on each stalk varies from about seven to sixteen, and the height of the stalk from three to twelve or more feet. The seed head may be large, loose, and open, as in the case of the amber sorghums, or it may be very close and compact, as in the milos. The seeds are usually spherical; in some cases their length is greater than their width, and they are often flattened, especially toward the base, where they are attached to the seed head. In some varieties the seeds are hard and flinty, while in others they are comparatively soft. Usually the seeds of the sweet sorghums contain tannic acid, which gives them a bitter and puckering taste. Depending on the variety, the stalks are very juicy and sweet, juicy without sweetness, or dry and pithy. The time required for maturing varies with the season, the locality,

A typical head of Red Amber sorghum.

A good head of Freed sorghum.

and the variety. Some will mature in sixty days, while others require one hundred and twenty days.

Kafir in the shock.

Habits of Growth. Sorghum seed requires a warm soil in which to germinate. Because of this fact, those varieties which have soft seeds require later planting than those with hard, flinty seeds. During the first three or four weeks after germination the sorghums make a very slow growth. During this period they are sending their roots deep into the soil and preparing for rapid growth later.

The sorghums require less water to produce a pound of dry matter than most other common field crops, and this makes them especially valuable where rainfall is limited.

The sorghums are considered drouth-resistant, however, largely because of their ability to stand for a considerable time during drouth without growth, and to recover and grow rapidly when conditions of moisture are again favorable.

They are able to withstand drouth because their leaves curl or roll tightly during severe drouth and practically stop the transpiration of water, or the passing of water from the leaves to the air. Corn possesses this power, but in much less degree.

Saccharine Sorghums. The saccharine sorghums are

distinguished mainly by an abundance of sweet juice in the stalks. This type of sorghum is used extensively for pasture, hay, silage, and the manufacture of sirup.

Non-saccharine Sorghums. The non-saccharine sorghums, commonly called the grain sorghums, are characterized by absence of sweet juice from the stalks. They are used principally for the production of grain, although they make good silage and fair fodder. Kafir is the most important member of this group. Its stalks are comparatively free from suckers, and are thick, heavy and leafy. The heads are always borne on erect stems. The seeds are slightly elongated, and are hard and flinty.

A good head of feterita.

The durra group of sorghums, of which milo is the most important, is distinguished by a comparatively pithy stalk, and a smaller amount of foliage than kafir. The seeds resemble a sphere that has been somewhat flattened. In some varieties the seeds are rather soft; in others, hard and flinty. The heads are either erect or borne on gooseneck stems.

A poor head of feterita.

Broom Corn. The broom corns are characterized by their long, loose, open seed heads, dry, pithy stalks, and comparatively scant foliage. After the seed has been removed, the head is known as the brush, and is used in the manufacture of brooms.

Seed-bed Preparation. The preparation of the ground for sorghums is as important as for corn. In the eastern part of the state, where rainfall is heavy, sorghums should be surface-planted. In the western part of the state, where rainfall is less, listing is the more satisfactory method. In handling ground with the lister it is usually best to blank-list in the fall, allowing the ground to lie rough during the winter, in order that any snows which fall may be caught in the furrows, and in order that the soil may not blow. In the early spring the ridges may be worked down with a cultivator such as is used for listed corn, or, where there is little danger of blowing, the harrow may be used. Just before planting time the ridges may be split with the lister; or, if it is more convenient, furrow openers may be attached to the ordinary corn planter, and the sorghum seed planted in the bottom of the furrows which were opened the previous fall.

Dwarf yellow milo.

Planting. The amount of seed to be planted on each acre will depend upon the rainfall, the length of the season, the size of the variety to be planted, the quality of the seed, the fertility of the soil, and the purpose for which the crop is to be grown. In broadcast seeding in eastern Kansas, from one and one-half bushels to two and one-half bushels usually gives the best results. In broadcast seeding in central Kansas about one and one-half bushels is most satisfactory, while in extreme western Kansas from three pecks to one bushel is best.

Broom corn. On the left, a head with seed removed; on the right, a head with seed. The cut shows a good type of head. Observe that there is no coarse center stem to cause the broom to wear unevenly.

In planting in cultivated rows for silage in eastern Kansas ten to twelve pounds of seed an acre has given excellent results, while in the western part of the state from six to eight pounds an acre has proved better than heavier seeding.

In western Kansas, when the crop is to be grown for seed production, four pounds to the acre of any of the common sorghums or kafirs is sufficient. If the seed is of low germinating power and possesses little vitality the amount used must be increased in direct proportion to the amount of seed which will not

grow. It must be remembered that sorghums are natives of a warm, dry climate and will not do their best in a cold soil. Those varieties which require a comparatively long time to mature must be planted earlier than those varieties which mature quickly. Ordinarily, plantings should be made from two to three weeks later than the plantings of corn in the same locality.

Cultivation. In western Kansas better results are usually secured if, instead of the common ridging of the rows, small furrows are left in the row when all cultivation is completed. In the case of surface-planted sorghums, the rows are usually ridged slightly at the last cultivation.

Harvesting. The time and the method of harvesting depend altogether upon the purpose for which the crop is grown. If the sorghum is grown for grain alone, the cheapest method is to harvest the heads from the standing stalks in the field. Where a considerable acreage of sorghum is grown machine heading may be profitably followed. The ordinary grain header, after the platform is elevated, can be successfully used to harvest dwarf varieties, such as dwarf milo planted so thickly that the heads will stand erect, and dwarf kafir. There are a number of single-row headers which can be attached to ordinary wagons, but none of them thus far has proved entirely satisfactory.

When it is desired to use the crop both for grain and for forage, most growers prefer to cut the crop when the seed is in the soft-dough stage. When it is cut at this period there is sufficient nourishment in the stalk to allow the seed to cure fairly well so that it is good feed, yet no leaves are lost, and the stalk has not yet become dry and pithy.

In cutting broadcast plantings for hay it is usually best,

in case there has been sufficient moisture to allow the crop to head, to wait until the seed is in the soft-dough stage.

When sorghums are cut in hot weather the juice is apt to ferment and reduce the feeding value. It is best to plant the sorghums at such a time that they will mature after hot weather is past, as they can then be more conveniently harvested and can be cured into better feed.

Sorghums should be cut for silage when the seed is just firm enough to be readily cut when pressed between the thumb nail and the finger. When harvested in this stage the sorghum makes a large yield of rich silage.

Storing. The proper storing of sorghums, as of any other feed, is important to every farmer. Sorghums will keep comparatively well if put into large shocks. If broadcast sorghum has been cut for hay, a shock of half a ton will keep for a considerable time in a dry region without much loss, though some feed is damaged by dirt blowing into the shocks, by mice working in the bottom of the shocks, and by exposure to the weather. It is desirable to stack the feed as soon as it is sufficiently cured. For general stock feeding, particularly of cattle and sheep, the most satisfactory method of storage is by means of the silo. The advantages of storing in the silo are that the feed is convenient to use; there is no loss by dust and dirt blowing into the stack; there is no rotting on the ground; rats, mice, and insects do no damage; and the feed is fireproof.

Threshing. In threshing sorghums great care is required to avoid breaking the seed. This is especially important in handling milo and feterita. For threshing these types at least one-half of the cylinder teeth should be removed from the thresher; in some cases a blank concave plate is used. It is also necessary to run the thresher

more slowly than for threshing wheat. Fewer seeds are broken if the sorghums are headed with stems from a foot and a half to two feet long, as this provides sufficient stems to prevent the cylinder teeth from beating against the grains so severely.

The Improvement of Sorghums. The one right place and the one right time to make selections of sorghum seed are in one's own field and before the first frost.

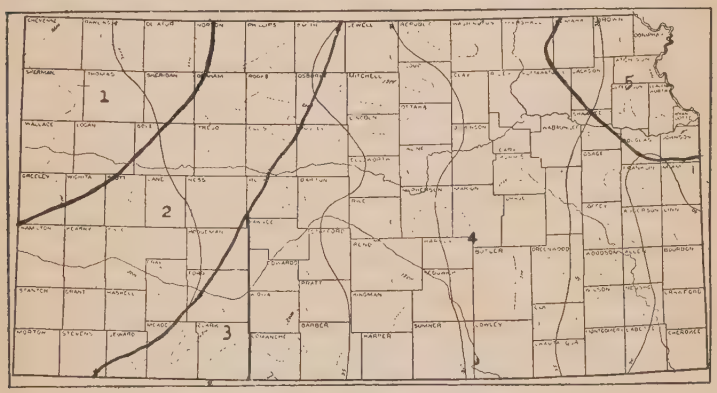
Sorghums cross-fertilize readily, and therefore seed selections should be made at least one hundred yards from any other variety. In selecting sorghum seed for forage, choose erect, leafy plants. Do not select those which have an excessive tendency to stool, nor those which produce side branches or suckers from the upper joints or nodes. Consider only those plants which ripen uniformly, and only those on which the main stalk and the suckers are of practically the same height and type. Find, if possible, an early-maturing plant, as this in many cases means drouth evasion, and may mean a crop when later-maturing plants would fail entirely.

In selecting seed for grain all points considered in selection for forage should be given attention, and, in addition, the heads should grow well out of the boot and the seed should not shatter. The heads should be of a fairly compact form and well-filled from butt to tip. Usually those heads which have short internodes, that is, short spaces between the joints, yield the most grain.

The selected heads should be either threaded on a string and hung from the rafters of the barn or granary where birds can not reach them, or piled loosely in sacks and hung where there is free circulation of air. They should not be threshed until near planting time. Sorghum seed that has been threshed heats readily when stored in bulk, and such seed is likely to be of poor germination.

Pasturing Sorghums. There is danger in pasturing sorghums, especially when there has been a period of drouth or when the sorghum growth has been stunted in any other manner. At such times kafir, milo, and all the sweet sorghums have been known to contain prussic acid, a quick-acting and deadly poison. There is no entirely satisfactory treatment for stock poisoned by prussic acid, though if the illness is discovered in time large quantities of glucose or cheap sirup may effect a cure.

Sorghum Regions Defined. As indicated in the accompanying map, there are five sorghum regions in Kansas, different varieties of sorghums being required for these several parts of the state. In region 1, where the altitude is great and the season short, dwarf milo, feterita, and Freed



Map of Kansas, showing the sorghum regions.

sorghum are grown successfully for the production of grain. Dwarf black-hulled kafir and white-hulled kafir mature grain in the more favorable seasons. Home-grown or northern-grown seed should be planted if possible. The Freed sorghum will mature in about eighty-five days. It does not make a heavy yield, but the fodder is of good

quality. Early-maturing strains of black and red amber sorghum will also mature seed in this region. These varieties and kafir are all suitable for forage production.

In region 2, dwarf black-hulled kafir, white-hulled kafir, milo, and feterita will mature seed in average seasons. Standard black-hulled kafir seldom makes a profitable seed crop. All varieties of kafir are excellent for forage. Freed sorghum, amber sorghums, and early-maturing varieties of orange sorghum do well in this area.

Dwarf milo, feterita, and Freed sorghum are well adapted to region 3. The kafirs are also dependable crops. Southern-grown seed will produce satisfactory crops in this region.

In southern Kansas, east of region 3, the variety known as sumac sorghum, also called redhead and redtop, is an excellent variety for forage purposes, but will not ripen seed every year. The Kansas orange will ripen in one hundred and fifteen days under average conditions, while the sumac will require from one to two weeks longer.

Throughout all of region 4, standard black-hulled kafir is the most profitable grain sorghum crop. In the northern two-thirds of region 4, Kansas orange sorghum is the most profitable forage variety.

In region 5 kafir makes a very good grain yield, but is not so profitable as corn. Dwarf milo is not satisfactory in this region, because the forage yield is small and because chinch bugs are especially attracted to it.

QUESTIONS

1. Why must sorghums be planted later than most field crops? Why would you select for sorghum planting a field free from weeds?
2. What are the various reasons why sorghums withstand dry weather so well?
3. How should the ground be prepared for sorghums?

4. Give several reasons why sorghums are crops well adapted to Kansas farms. The reasons should pertain to soil, climate, and the value of the crop for feeding.

5. Give all the different conditions which determine when sorghums should be planted and how much to plant to the acre.

6. How should sorghums be planted in eastern Kansas? In western Kansas? What are the reasons for these differences? How much seed should be planted on an acre in each part of the state?

7. How should one harvest and care for a crop of sorghum grown for hay? for grain? for both grain and fodder?

8. What are the advantages of storing the sorghum crop in the silo? When should the crop be cut for silage?

9. How would you attempt to improve a strain of sorghum which you were growing on your farm? What are the characters you would consider in selecting seed to improve the stand? How should the seed be stored? Why?

10. Make a list of the kinds of sorghum you would plant for hay; for grain; for sirup. Give your reasons for your choice in each case.

11. How does broom corn differ from other sorghums? Why is Freed sorghum adapted to northwestern Kansas?

CHAPTER VIII

WHEAT

Wheat was cultivated for food in Egypt before the pyramids were built, and in China at least 2700 years before the birth of Christ. The wheat plant in those early times was much as it is to-day, but the methods of growing, harvesting, and preparing it for food were very different.

Wheat is supposed to have been developed from a wild plant in much the same way that our present breeds of cattle were developed from the wild cattle of Europe. The wheat plant grows wild in Palestine. The grains are longer and more boat-shaped than those of domestic wheat. In the wild plant the chaff adheres to the grain when threshed. It is supposed that before wheat was cultivated the wild wheat was gathered for food. Naturally the largest, best-appearing heads of wheat, and those containing the most and the best grain, would be selected first. Some of these perhaps became scattered, and grew about the dwellings. The best were again selected. After this had continued for many centuries and in different parts of the world, varieties very much like the ones we grow at present were developed.

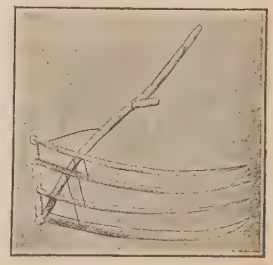
The ground in early times was plowed with a crooked stick drawn by women or oxen. By this means the ground was merely loosened on the surface. The grain was sown by hand. The farmers covered it by dragging the top of a tree over it, or by driving herds of cattle over the

field. Of course, when grown by these methods the yield was very small. At first men harvested the grain by pulling up the entire plant or by breaking off the heads. A sort of stone sickle was sometimes used, which would half cut and half break the straw. When man began to use iron, sickles were made of this material.

A grain sickle. One of the early implements used in harvesting wheat.

A great advance was made by the invention of the cradle. The cradle came into general use during the time of the Roman Empire, and remained the principal means of harvesting wheat for many hundreds of years.

More progress has been made in methods of harvesting wheat in the last seventy-five years than during all the centuries before. The beginning of advancement was the invention of the reaper in 1835 by Cyrus Hall McCormick, a Virginia farmer and blacksmith. The most epoch making improvement upon McCormick's reaper was John P. Appleby's invention of the machine to tie the bundles. Out of this the modern self-binder grew.

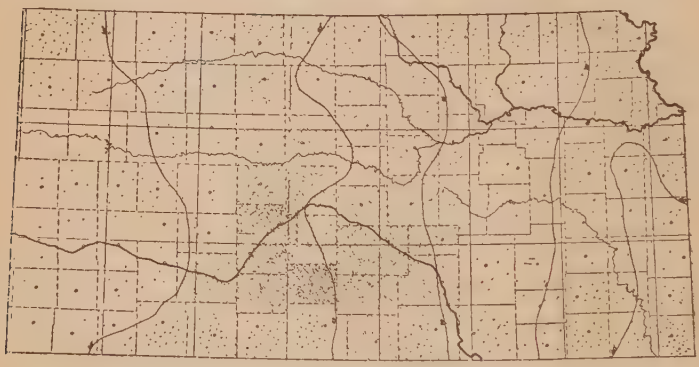


An old-style grain cradle.

Types of Wheat. Wheat may be classed as winter or spring, according as it is adapted for seeding in the fall or in the spring. If spring wheat is sown in the fall, it will be killed before spring by cold, except in very mild winters. If, on the other hand, winter wheat is sown in the spring it will not produce heads. It is necessary that winter wheat

pass through a dormant, or resting, stage, brought on by cold weather, before it will joint and produce heads.

About seventy per cent of the wheat of the United States, and practically all that of Kansas, is winter wheat. It yields more than spring wheat, and as it ripens earlier it often escapes drouth, hot winds, rust, grasshoppers, and other things that damage spring wheat. Spring wheat is grown principally in Minnesota and the Dakotas, where the severe winters kill winter wheat.



Map of Kansas, showing the production of wheat, average of five years, 1909-1913. One dot represents ten thousand bushels.

The principal kinds of spring wheat grown in the United States are the Fife wheats, the Bluestem wheats, and the Durum wheats. Each of these is subdivided into varieties.

Winter wheats are usually divided into two classes, the hard winter wheats, such as Turkey and Kharkof, and the soft winter wheats, such as Fultz, Harvest Queen, Zimmerman, and Fulcaster. By far the largest quantity of wheat grown in Kansas is of the hard winter type.

Varieties of Wheat. Some kinds of wheat have beards, some have smooth chaff, while the chaff of many varieties is covered with fine velvety hairs. There is much variation in the height of the straw, in the color of the chaff, and in the color, the size, the shape, the hardness, and the

Heads of different kinds of wheat.

1. Polish wheat.
2. Durum wheat.
3. Hard spring wheat.
4. Hard winter wheat.
5. Soft winter wheat.
6. Alaska wheat.
7. Club wheat.

quality of the grain. Experience has proved that the best varieties for most of Kansas are the Turkey and the Kharkof, which are nearly the same. The Turkey and Kharkof varieties are bearded, have smooth chaff but very hard grain, and make excellent flour.

In the eastern part of Kansas, the Fultz, the Zimmerman, and the Harvest Queen, all of which are beardless and have rather soft, large grains, usually give the largest yields.

Before the introduction of the Turkey and Kharkof varieties from Russia, about thirty-five years ago, these large, soft-grained wheats were the only ones grown. They were not well adapted to the Kansas climate and consequently gave small yields and sometimes failed entirely. As the Turkey and Kharkof wheats had probably been grown in Russia for centuries and had become adapted to conditions like those of Kansas, they immediately proved successful.

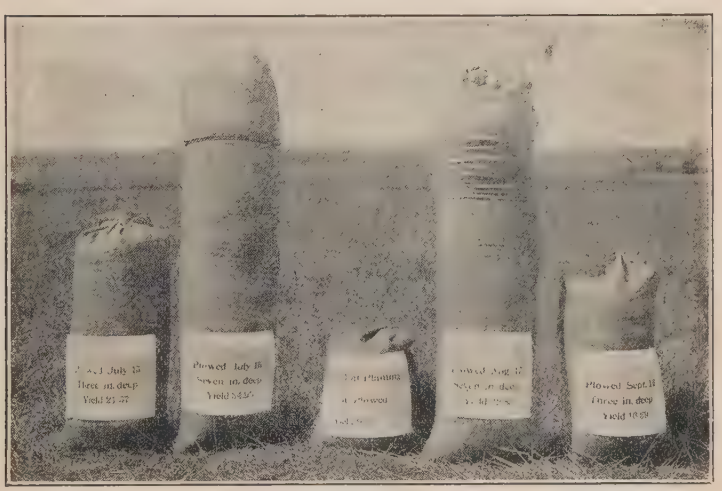
The introduction of Russian wheat into Kansas increased the yield of wheat not only in Kansas, but in the United States as well, since it made it possible to grow winter wheat much farther north in the United States than would otherwise be possible.

Preparation of the Ground. In many ways the preparation of the ground is the most important part of growing wheat. The soil is a sort of reservoir, which should be stored with moisture and plant food, and then covered with a layer of loose earth to retard loss of moisture until the plant can use it. Plowing and cultivating the ground put it into condition to absorb rains and unlock plant food, and also provide the layer of loose earth that prevents, so far as possible, loss of these materials.

When wheat is grown on corn ground very little preparation is necessary. In fact, the cultivation given the corn prepares the ground for wheat, so that about all that is necessary is to disk the ground well before the grain is sown.

When wheat follows a small-grain crop, like wheat or oats, it is essential to plow or list the ground.

Early Plowing. The most important matter in plowing ground for wheat is to plow early, just as soon after harvest as possible. This puts the surface into condition to absorb rain, liberates plant food, and gives the ground time to settle before the grain is sown. The value of early plowing



A contrast. Wheat grown upon one-tenth of an acre of land, showing the effect of five methods of preparing the ground where wheat has been continuously grown. The method of preparation has been the same in each case for the previous three years.

is shown by the results of an experiment conducted at the agricultural college at Manhattan, in which the yield from the ground plowed July 15 was twenty-seven bushels an acre; the yield from the ground plowed August 15 was twenty and a half bushels an acre; and the yield from the ground plowed September 15 was fifteen bushels an acre. In this case the gain from early plowing was twelve bushels, worth, at 80 cents a bushel, $9.60.

When ground can not be plowed immediately after harvest, it should be disked. Disking prevents, to a large extent, loss of moisture from the soil until the ground can be plowed. In another experiment conducted at Manhattan, disking immediately after binding increased the acre yield of wheat eleven bushels, worth $8.80.

Depth of Plowing. Plowing should be deep enough to turn all trash and straw under. It is seldom advisable to plow more than seven or eight inches deep, but there is more danger of plowing too shallow than too deep. Ground should not be plowed to the same depth every year. If this is done, a kind of hardpan forms at the bottom of the furrow, which to some extent prevents the penetration of rain and of the wheat roots into the unplowed part of the soil. The formation of this hardpan is prevented by rotation of crops and plowing to a different depth for each crop. If a field grows first corn, then oats, then wheat, then corn again, it may be plowed eight inches deep for corn, disked for oats, and plowed five inches deep for wheat.

A fanning mill.

Working the Ground after Plowing. If ground remains rough, as left by the plow, it will lose by evaporation practically all the moisture it contains. For that reason, ground that is plowed when in good condition should be harrowed or disked soon after being plowed. Ground that is too dry to plow may be disked and then left until a soaking rain, when it should be plowed. Ground that is

dry when plowed may remain without further attention until rain falls. It should then be worked, in order to prevent the loss of moisture added by the rains.

Listing the Ground for Wheat. In central and western Kansas the ground is often broken with a lister soon after harvest. The ridges are then gradually worked down, so that by seeding time the ground is level again. This method of preparation is more rapid and cheaper than

A field of Turkey wheat which yielded 58.6 bushels an acre. Early plowing and good preparation of the soil were mainly responsible for the yield.

plowing, and for many conditions is just as good. It has this disadvantage, however, that when land is prepared in this manner year after year, there is a tendency for the lister to run in the same furrows, so that a part of the ground is never stirred. To avoid this condition the land may occasionally be plowed or listed at right angles to the old furrows.

The Kind of Seed to Sow. Wheat that comes from the threshing machine usually contains weed seed, dirt, chaff, bits of broken straw, and small, shriveled kernels. Such wheat is unfit for seed. A weed requires as much moisture and plant food as a wheat plant, and every weed reduces the yield of wheat just so much. Chaff and straw may

clog the drill. The small and shriveled kernels will not produce so strong plants as will the good, plump kernels. The vigor and strength of the wheat plant in its early life depend very much upon the amount of food material stored in the seed.

All foreign matter and small, shrunken kernels should be removed. This can best be done by means of the fan-

A good seed bed for wheat.

ning mill. If the wheat contains smut, the grain should be treated to prevent this disease in the following crop.

The Methods of Seeding. Wheat may be sown broadcast or with a drill. In the former case it is scattered

uniformly over the ground and covered by disking or cultivating. The drill puts the seed directly into the ground. While broadcasting is slightly faster and cheaper than drilling, the latter is the better method. When wheat is drilled less seed is required than when it is sown broadcast; the drill places it in direct contact with moist soil, which insures prompter and more nearly complete germination. The plant makes a more rapid, vigorous growth if drilled, and is not so likely to winterkill.

The Time of Seeding. Winter wheat must be sown early enough to enable it to get a good start and to develop strong roots before winter, else it may winterkill. On the other hand, it should not make too much growth before winter, or it will use moisture that should be saved for spring or summer growth. In eastern and central Kansas, where the Hessian fly sometimes injures wheat, seeding should be done just late enough to avoid the fly.

In western Kansas it is usually necessary to seed wheat when there is sufficient moisture to germinate the seed promptly. It is usually not good practice to sow wheat in dry soil. There may be just enough moisture present to enable molds and bacteria to grow, and these will cause the grain to rot; or a light rain may sprout the grain but not furnish enough moisture to keep it growing. The best method is to have the ground, the seed, and the drill in readiness. Then, when a good rain comes the grain should be put in as quickly as possible thereafter.

If rains occur as early as September 15, the grain should be sown at that time. If not, seeding may be delayed almost until winter, in preference to seeding in dry soil.

The Rate of Seeding. The amount of wheat which should be sown to an acre depends upon several factors. In case of an abundance of moisture and plant food, the

yield of grain will be much greater when there are a large number of plants to the acre. In a dry year or on a poor soil, however, there may not be sufficient water or plant food to bring so many plants to maturity. For this reason the rate of seeding should be different in different parts of the state and on different soils. In eastern Kansas, where there is abundance of moisture, one and one-quarter or one and one-half bushels of grain is usually sown to the acre; in central Kansas, one bushel an acre is enough, while in western Kansas, three pecks, or even two pecks, of good

A field of Turkey wheat in the shock.

seed is ample. The quantity of seed that should be sown depends also upon its quality, upon the preparation of the ground, and upon the method of seeding.

The Depth of Seeding. Wheat should be sown just so deep that it will be in moist soil, and that it will not dry out before it germinates and sends its roots into the subsoil. If the seed is sown deeper than this the plant will be slow in coming up, and in the event of unfavorable conditions may die before reaching the surface.

The depth necessary for the best results varies with soil and climate. On a light soil the grain may be sown deeper than on a heavy soil, and in a dry climate the grain should usually be sown deeper than where rain is plentiful. In eastern Kansas the best depth is from one to one and one-half inches. In western Kansas wheat is usually sown from one and one-half to three inches deep.

The Tillering of Wheat. The stem, when it first appears above-ground, broadens out into a leaf. After a few days a second leaf appears, surrounded by the first; and in a few more days a third, surrounded by the second. In case of winter wheat these leaves become separated from each other and flatten out on the ground. This process occurs from two to four weeks after the grain is up. It is known as stooling, or tillering. From each of the first tillers others are formed in the same way, until there may be as many as fifty or one hundred tillers from each seed. Tillering takes place more abundantly when the soil is rich and where the wheat has been planted thinly.

About a month after wheat begins to grow in the spring each of the tillers begins to shoot; that is, it sends up a shoot, inclosing a head.

Harvesting Wheat. Wheat continues to gain in weight until it is ripe, though the increase is very slight during the last few days of growth. The best time to harvest is when the grain is in the hard-dough stage.

Pasturing Wheat. When wheat makes a good growth in the fall it forms excellent pasture for horses, cattle, and sheep. If judiciously carried on, pasturing will not materially injure the wheat. Stock should never be turned upon wheat fields when the soil is wet, else much of the wheat may be tramped out and the physical condition of the soil be greatly injured.

Late spring pasturing is very detrimental, and is sure to reduce the yield of wheat much more than will be compensated for by the value of the pasture.

QUESTIONS

1. How long has wheat been grown for food? How have the methods of harvesting changed?

2. Does the depth of seeding have any relation to the depth to which the roots extend? What relation does soil fertility have to tillering?

3. Name two of the best varieties of wheat for Kansas. Are these varieties best for all parts of the United States? Why?

4. What is meant by winter wheat? spring wheat? What are the advantages of winter wheat where it can be successfully grown?

5. Why is preparation of the ground for wheat important? What is a good method of preparing the ground for wheat? Why is this a good method?

6. How deep should ground be plowed for wheat? Why is disking after harvest usually a good practice? Where is listing a feasible method of preparing ground for wheat?

7. In what way do time of plowing and rotation of crops affect depth of plowing?

8. Why is drilling a better method of seeding than broadcasting? How should seed be prepared for seeding? What conditions determine the depth of seeding?

9. When should winter wheat be sown in Kansas? Why should it not be sown too early? too late?

10. How much wheat an acre should be sown in eastern Kansas? in western Kansas? Why this difference?

CHAPTER IX

OATS AND OTHER SMALL GRAINS

From thirty-five to fifty million bushels of oats are grown each year in Kansas. These oats are worth from $12,000,000 to $15,000,000, or about one-fifth the value of the corn crop, and about one-fourth the value of the wheat crop. The average yield of oats is approximately twenty-five bushels to the acre. This is but slightly more than the average yield of corn for the entire state. Oats are therefore relatively an unprofitable crop except for their value in crop rotation.

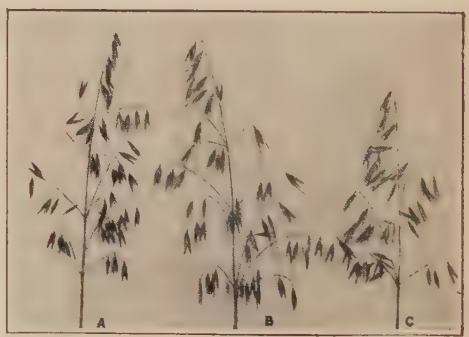
Oats are grown for two reasons: first, because they are desired for feed for horses; second, because in many parts of the state there is not time enough after corn is taken off to prepare a good seed bed for wheat. Since oats are a spring crop, they may be sown after corn, and may be followed by wheat. In this way a larger profit from the land may be obtained in the three years required for the rotation than would be obtained if wheat were sown after the corn, and followed by corn again.

An oat flower.

Northern Oats. Many farmers send to Canada or the northern states for seed oats, because of the better quality of grain that can be obtained there. Montana- or Canadian-grown oats often weigh fifty pounds to the bushel, while Kansas-grown seed weighs

thirty or thirty-two pounds to the bushel. Northern-grown oats, however, require much longer to mature than do the varieties best suited to Kansas; consequently, the northern varieties are forced to mature here during the hottest, driest part of the year, while the earlier varieties will be ripe before the hot weather arrives. As oats are especially susceptible to hot weather, it often happens that northern-grown oats will be practically a failure, while adapted varieties will make fair yields.

Types of Oats. There are both winter and spring types of oats. Where they do not winterkill, winter oats produce much better yields. Unfortunately, winter oats have not been found hardy except in the southernmost part of the state, and there only in mild winters.



Varieties of oats: *A*, Red Texas; *B*, Kherson; *C*, Burt.

Experiments conducted by the agricultural college in different parts of the state show that Red Texas and Kherson are best for eastern and central Kansas. Farther west, the Burt oats, which are somewhat earlier, appear to give the best results.

The Preparation of the Ground. When grown in Kansas, oats usually follow corn. The ground may be plowed in the fall or in the spring, or it may simply be well disked before seeding. Probably the best method, where the ground is clean, is to sow the oats on disked corn land. In eastern Kansas there are some advantages in fall plow-

ing. Seeding may be done earlier on fall-plowed ground than on unplowed stubble ground.

Time, Rate, and Method of Seeding. In general, the earlier oats can be sown in the spring the better. They will stand considerable cold weather without injury.

The rate of seeding depends on the rainfall and the soil. On very rich soil in eastern Kansas three bushels may be sown to the acre. In central Kansas two to two and a half bushels an acre is sufficient, while farther west it is never advisable to seed more than two bushels to the acre, and less is often better.

Though oats are often sown broadcast, a better way is to seed them with a drill. Less seed is required, and germination is quicker and more nearly uniform and complete.

The Kind of Seed to Sow. Many farmers believe that oats run out; that is, that the quality of the seed gradually becomes poorer and poorer. This is believed to make a frequent change of seed necessary. If oats are cleaned and graded and care is taken to retain only the heaviest, plumpest kernels, the oats will not run out, but will become better each year. The climate of Kansas will not produce so heavy and plump an oat as will the climate of Montana or of Canada. The fact that seed oats weighing forty-eight to fifty pounds a bushel produce oats weighing only twenty-five to thirty pounds is no indication that the variety is running out.

Barley. Barley is a good feed for hogs, and it would probably be a good substitute for oats in many localities where the tendency is to grow more oats than can be used on the farm. Barley requires less water than oats, and usually produces larger yields. The principal objection to the crop is that it is especially susceptible to damage by

chinch bugs. Where these insects are likely to infest the fields severely, barley should not be grown.

There are both winter and spring types of barley. Spring barley is most extensively grown in Kansas, but winter barley gives the best yields in places where it is hardy. Winter barley can be grown successfully as far north as Manhattan, about four years out of five.

Types of barley: *A*, Two-row barley; *B*, Hull-less barley: *C*, Six-row barley.

There are several kinds of spring barley. The most important are six-row, or common, barley; two-row barley; beardless barley; and hull-less barley. The six-row barley is most commonly grown in the state, and usually gives the best results.

The beardless and hull-less kinds are more convenient to handle, but they usually yield much less than do the common six-row sorts.

Barley, like oats, should be sown as early in the spring as the ground can be prepared. Usually about two bushels of seed are sown to the acre. Winter barley is sown at about the same time as winter wheat, and at the rate of from one and one-half to two bushels an acre.

Emmer. Emmer, or speltz, as it is commonly called, is grown to some extent in Kansas. It is a kind of wheat, but differs from wheat mainly in that the chaff remains attached to the grain after threshing, as it did to wheat originally. The grain is very hard, is of a red color, and is long, slender, and somewhat boat-shaped. Emmer is not so convenient to handle as are oats, for the heads are bearded and the straw is very slippery, which makes it difficult to bind and stack. Emmer is used for horse and

hog feed as a substitute for oats and barley. The straw is of practically no value for feed, being worth even less than wheat straw for this purpose.

Emmer is sown in the spring, about the time that oats and barley are sown. Two and one-half bushels of seed is sown to the acre.

Flax. Flax is sometimes grown on new land in Kansas, because it may be sown later than most other small grains and make a crop. The yield is usually small, so that the crop ordinarily proves unprofitable except when prices are high. Flax must be sown on ground that is free from weeds, as it makes a very open growth, which allows weeds to grow and finally choke out the crop. If flax is grown on the same ground year after year the soil is said to become "flax-sick." This condition is due to a fungous disease which attacks the growing plant and causes it to rot off at the surface of the ground. This disease is carried in the seed; consequently clean seed, free from the disease, is essential. The disease may remain in the soil for several years. If the soil becomes affected, flax should not be sown on it again for at least five years.

Flax is sown about corn-planting time or a little later, at the rate of about one-half to three-fourths of a bushel to the acre. It is sometimes harvested with a binder, but is not bound, as the branching heads serve to hold the bundles together. It is sometimes left on the ground until it is threshed, although this is not a good practice, as flax is likely to be greatly injured by wet weather. A better way is to bind it loosely with twine and shock and stack it, as is done with wheat or oats. The stacks must be covered with straw or hay, as flax straw will not readily shed water.

The seed of flax is used for making linseed oil, and the cake, after the oil has been pressed out, is a valuable stock feed and is known as oil cake or linseed meal.

QUESTIONS

1. How do oats compare with wheat and corn in value? yield to the acre? value to the acre?

2. Why is the yield of oats to the acre so low in Kansas? Why are oats grown in Kansas?

3. Where should the farmer secure his oats for seed? Why? Is a frequent change of seed oats necessary?

4. What are winter oats? Why are they not more generally grown?

5. What are the advantages of fall plowing for oats?

6. Upon what does rate of seeding depend?

7. How does the yield of barley compare with that of oats? Why is barley not more generally grown?

8. Name three kinds of barley. How far north may winter barley be grown?

9. How does emmer differ from wheat?

10. Why is it more important to seed flax on ground free from weeds than to take this precaution for other grain crops?

11. What is meant by "flax-sick" soil?

CHAPTER X

HARVESTING, MARKETING AND MILLING WHEAT

Where wheat is sent to market its value is judged largely by the appearance, the quality, and the weight of a measured bushel. There is seldom any doubt about the fitness for milling purposes of wheat that has been harvested at the right time and properly handled, but only the expert miller is able to tell the value of damaged wheat, and the buyer, desiring above all things to protect himself, usually pays less for damaged wheat than it is really worth.

Methods of Harvesting Wheat. In the eastern third of Kansas the wheat is cut with a self-binder, and most of it is stacked. In the central third of the state both the self-binder and the header are used. Much of the wheat cut with the binder there is not stacked, but stands in the shock until it is threshed. While remaining in the shock it is not well protected from rain and dew, and consequently is likely to become damaged by sprouting or molding.

In parts of the central third of the state, and throughout the western third, the header is used almost exclusively. The wheat is allowed to become overripe, then is cut and stacked at once. The stacks of loose grain do not turn water readily, and must be properly built or much of the wheat in them will be damaged.

The Effect of Methods of Harvesting on Quality. By far the largest acreage of Kansas wheat is produced in the

central third of the state, where the practice of threshing from the shock prevails. A very large proportion of the wheat stands in the shock from three to six weeks, or even longer, and in this period there often takes place a heavy rainfall, which frequently injures for flour-making purposes what would have been a good quality of grain. Sometimes this result is unavoidable, but more often it is due to carelessness. If wheat is to remain in the field for any length of time it should be well shocked and capped. Even in well-made shocks which are allowed to stand for some time, the wheat on the exposed parts of the bundles may be seriously injured. Exposure in the shock to alternating rain and hot sun causes the kernels to swell and the branny coat to loosen, destroying the natural color, or "bloom." This gives the wheat what is termed a bleached appearance. In threshing, this poor wheat is mixed with good, and the grade and the market value of the whole are lowered.

In the large markets wheat is sold according to grades. The grade given a carload of wheat depends largely on its appearance, its condition, and its test weight. It is a matter of common knowledge among farmers that when shocked wheat is exposed to a shower it not only loses natural color, or "bloom," but may lose as much as a pound to the measured bushel. Sometimes exposure to rain causes the wheat to sprout, and since sprouted wheat does not make a good quality of flour the value of the crop is further reduced.

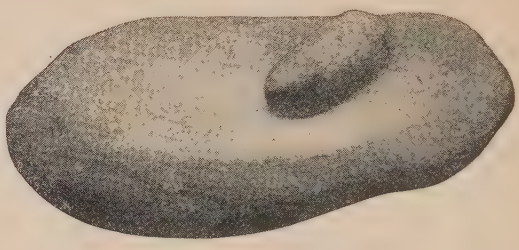
Sweat in Wheat. When wheat is stacked it goes through a process called sweating, in the stack. Wheat threshed from the shock goes through the sweat in the bin. Buyers and millers prefer wheat that has gone through the sweat, and they insist that sweating in the

stack improves the quality of the grain over sweating in the bin. Very little is known concerning what changes take place when wheat sweats. Sweating is probably due to chemical changes. Whatever change occurs is accompanied by heat. Sweating does not take place until the wheat has been brought together in large bulk. The amount of heat generated appears to be influenced by the amount of moisture present. Grain that has been sufficiently ripened and is also very dry will give little evidence of change in temperature in going through the sweating process. On the other hand, wheat cut in the hard dough stage, or containing considerable moisture, goes into the sweat much more quickly when stacked; a great deal of heat is produced, and the straw becomes very tough. Care should be taken not to stack it until it has cured in the shock for a few days; otherwise sufficient heat may be produced, even in the stack, to injure the grain. Wheat thus injured is known as stack-burnt wheat.

Heat-damaged, or Bin-burnt, Wheat. When a large amount of wheat containing much moisture is placed in a bin there is very little chance for circulation of air, and the heat generated is retained in the grain. Finally the temperature becomes so high as to cause what is commonly known to the grain trade as heat-damaged, or bin-burnt, wheat. The injury may extend only into the branny coats and produce slightly heat-damaged, or bran-burnt, wheat, or it may extend throughout the endosperm and produce badly heat-damaged, or bin-burnt, kernels. Wheat in the latter condition is practically unfit for flour-making purposes.

Milling Kansas Wheats. Kansas produces annually from nine and one-half to eleven million barrels of flour. Since it takes approximately four and one-half bushels of

wheat to make a barrel of flour, the amount of wheat ground is from forty-three to fifty million bushels—about half the usual yield. The Kansas winter wheats have exceptional gluten quality, or "strength." This is an important quality in wheat, and consequently wheat possessing it is much sought after for making the best flours.



An early Indian mill (mortar and pestle).

The old mill at Lawrence, Kansas.

When central and western Kansas began to be settled it was found that the soft winter wheats, such as Big May, Little May, Gold Drop, Fultz, and Bluestem, grown in the eastern part of the state, did not withstand so well the more rigorous winters and hot, dry summers of the central and western counties.

In the early seventies some Mennonite settlers from southern Russia brought to Marion county the seed of a hard red winter wheat which had been successfully grown under the severe conditions of their native land. This wheat yielded well under the new conditions, and gradually became widely grown in Kansas.

The new wheat was very hard, and therefore did not suit the Kansas miller, since he could not prevent the branny coat from powdering up until it became so fine that it could not be separated from the flour middlings.

For that reason, the price of the hard winter wheat declined until it sold for twenty-five cents a bushel less than soft wheat. Because of its cheapness Kansas millers began trying to use this hard wheat. Finally, when chilled-iron rollers came into use, about 1881, and when the process of tempering or wetting the hard wheat to prevent the

A modern Kansas mill.

branny coat from breaking up into fine particles was discovered, the millers were able to use this wheat successfully. Soon thereafter this hard wheat became very popular. The millers had learned how to mill it, and its high gluten content produced a superior flour. In a short time foreign bakers and millers learned the value of flour made from Kansas hard wheats. The Kansas miller was not slow to follow up this demand, and before long the products had even a greater reputation abroad than at home. Thus developed the Kansas export trade in wheat and flour.

FLOUR MANUFACTURE

The first milling was done as by the Indians, with mortar and pestle. Later, stone burrs were introduced, and the flour was sifted, or bolted. Still later, the stone burrs were displaced by steel rollers with both smooth and

corrugated surfaces. Millers also learned to clean and temper properly the wheat before grinding it. Finally, better sifters, or bolters, purifiers, reels, and flour dressers were invented.

The modern process of flour manufacture is far more complicated than was the process in the days of our forefathers. Then a small quantity of wheat, called a grist, was taken to the old stone burr mill, where it was ground into unbolted wheat meal, or what is now known as Graham flour. The miller kept a portion of the grist, usually from one-twelfth to one-sixth, as toll, or pay for grinding. A little later an improvement was made in that the ground product was sifted, or bolted, to remove the bran and poorer grades of the material. The demand for white flour led to one improvement after another, until we have the gradual reduction process of to-day, producing high-grade, purified flour.

The modern process consists of the following steps:

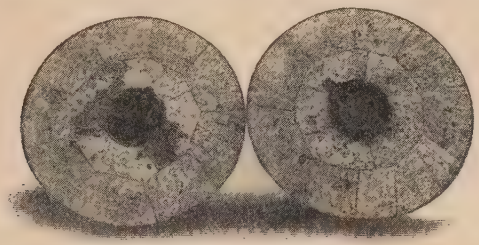
I. Preparatory—
   1. Cleaning.
   2. Scouring.
   3. Tempering.

II. Milling—
   1. Breaking.
   2. Sifting, or bolting.
   3. Purifying.
   4. Reducing.
   5. Dressing.

A sectional view of modern double-stand steel rolls.

Cleaning. The wheat, as it comes to the miller, contains more or less foreign material, including other grains. Most of this material is removed in a preliminary cleaning over the receiving separator. This machine is simply a

large fanning mill, which, by means of screens, air blast, and suction, removes the coarse material, such as sticks and straws, and also the fine material, consisting mostly of weed seeds and dirt particles. The final separations



A pair of burr stones, used before the advent of steel rolls.

are made by means of an improved cleaning machine known as a milling separator. This removes practically all the remaining foreign material.

Scouring. There still remain, however, fine dust particles clinging to the kernel, expecially in the crease, and these are removed by scouring, but usually not with water. In this process the kernels are thrown, by sets of beaters, with considerable force against the slightly roughened iron sides of the scouring case and also against each other. The dust particles, the fine hairs, and the small bran particles are thus loosened, and are then removed by strong suction applied at one end of the machine. All fine material removed from the cleaning and scouring machinery by air-suction currents is conveyed through spouts to dust collectors. This prevents such material from flying about in the mill and getting mixed with the flour.

Tempering. After the wheat has been cleaned and scoured, it is usually necessary, in order to prevent the branny coat from grinding up so fine that it will pass through the bolting cloth into the flour, to add to the

wheat a little water or to apply heat, or to do both. This is called tempering the wheat. Tempering is especially necessary with hard wheats, because of the more brittle character of their bran.

Breaking. After these preparatory steps the wheat is ready for the rolls, and the real milling process begins. Milling consists in a gradual reduction of the endosperm, in which operation the branny coat and the germ are removed. The cleaned and tempered wheat is passed between pairs of steel rolls, which gradually reduce the particles to smaller size. The first pairs of rolls used have fine grooves on the surface, and hence are called corrugated rolls. There are usually from three to five pairs of these, which are referred to as the break rolls. One roll of each pair turns about two and one-half times faster than the other, thus producing a sort of shearing, tearing, or grinding motion, instead of simply crushing or squeezing the broken grains.

Sifting or Bolting. Each time after passing between a pair of rolls, the stock—the partly ground product—is sent through spouts to a sifter, or bolter, where sieves with meshes of different sizes placed one above another separate the particles according to size and character. The largest particles are "scalped off"; that is, do not go through the top sieve, but pass over the lower end to the next machine, or roll. After the coarser branny particles have passed through the several pairs of corrugated rolls, the endosperm has been practically all removed, and the finished flakes of bran have been "scalped off." Those particles fine enough to go through the finest silk bolting cloth are finished flour.

Purifying. Particles of endosperm more or less free from bits of bran are separated, according to size, by the other sieves. The large granular particles, which closely

resemble corn meal, and are too coarse for flour, are called middlings. These are passed through purifiers, where gentle suction currents of air lift off the light branny particles and fluffy cellulose matter until there remain purified middlings which are ready for reduction.

Reducing. Next comes the gradual reduction of the middlings until they become fine enough for flour. This is done by passing the stock between pairs of smooth rolls, each succeeding pair being set a little closer together so as to grind a little finer. Every time the stock is ground by a pair of rolls it is elevated to a section of a sifter which grades the particles according to size and takes out the fine flour. This fine flour may be resifted or bolted on reels or flour dressers; this last step in the process is referred to as dressing.

Since the milling process is not perfect, the stock from near the end of the process, or "tail of the mill," contains a very large proportion of fuzzy, fibrous material and finely ground bran. A small amount of poor, or low-grade, flour is separated from this; the rest, together with separations of somewhat similar character coming from the purifiers, goes to make up what is termed shorts.

Proportion of Total Products. A good sample of Kansas Turkey wheat properly milled will yield approximately the following percentages: bran, 11 per cent; shorts, 15 per cent; total flour, 73 per cent. This allows for one per cent loss through evaporation of moisture and the escape of fine dust particles.

The total flour produced may be divided into different grades. The last one and one-half to three per cent of flour obtained at the "tail of the mill" is usually termed low-grade flour. If all the rest of the flour is packed together, it is called straight flour.

On the other hand, if the flour made by the earlier reductions of the purified middlings is separated from the rest it is termed patent flour, and the rest, composed of the later reductions and the break flour, is referred to as clear flour. When made from the same lot of wheat in the same mill the clear flour contains more gluten than the patent flour, but this gluten is not of so high quality.

QUESTIONS

1. Mention some ways in which wheat is injured in value during harvesting. How does such wheat differ in appearance from good wheat? Why must it be sold at a lower price?
2. Describe the usual method of harvesting wheat. What mistakes are frequently made in caring for wheat during harvest?
3. Which method of harvesting do you consider the better? Give reasons for your conclusions.
4. What do we mean by sweat in wheat?
5. What is the history of the introduction of Turkey wheat into Kansas?
6. Mention some of the improvements made in the process of milling.
7. Of what does the modern process of milling consist?
8. What is the purpose of tempering wheat, and how is it accomplished?
9. How does the sifting process differ from the purifying process?
10. How do the resulting finished products differ?

CHAPTER XI

LEGUMES

The grasses, including corn, wheat, and oats, as well as pasture and meadow grasses, are the most important crops on the general farm. Next in importance to this great grass family comes the pulse family, or the legumes, as the plants of this family are usually called. The common legumes, such as alfalfa, sweet clover, and red clover, are branching, spreading plants which may become woody by fall, but die to the ground in winter.

Description of Legumes. The most distinguishing character of the legume is the flower, which is always like the sweet pea, except that in most cases it is smaller. This flower is made up of an upper broad petal called the standard, two spreading petals called the wings, and two lower petals united to form what is called the keel. These petals of the keel inclose the stamens and pistil. To fertilize the legumes it is necessary to force the stamens and the pistils out of the keel. The seeds are borne in pods, which may be straight or variously coiled. Legumes have taproots or branching taproots which send out great numbers of fine branching rootlets. Some of the legumes, such as beans and peas, do not send their roots very deep into the soil, while others, like alfalfa and sweet clover, penetrate to a depth of several feet.

The Importance of Legumes. The most important and interesting fact connected with the growth of legumes is their power to secure nitrogen from the air. Nitrogen is found as a free gas in the air, but most plants can not make

use of it until it is combined with some other elements to make what we call nitrates. Nitrogen is essential to all plant and animal growth, however, for it is necessary to the formation of protein, without which there can be no life. The most expensive plant and animal foods are those which contain nitrogen. Since legumes are able to secure nitrogen from the air, they are of great economic importance to the farmer. They are important, first, because they may add nitrogen compounds to, instead of taking them from, the soil, especially if they are plowed under or returned to the soil in manure; secondly, because they contain a large proportion of protein and are therefore very valuable feeds for live stock. Consequently, legumes are grown both as soil improvers and for plant and animal food.

How Legumes Gather Nitrogen. The method of gathering and fixing nitrogen is very interesting. Legumes can do this only through the aid of bacteria which live in little lumps, or nodules, on the roots of the plants. Ordinarily, when alfalfa or clover is dug up the nodules are torn off, so that many people never see them. If we dig up a young plant of alfalfa, together with a lump of dirt eight or ten inches in diameter and a foot deep, taking care not to break and shatter the dirt, we may wash the roots clean and see the small, light-colored nodules. The washing must be done very gently, because the nodules are easily broken off. Nodules vary from the size of a pinhead to that of a small marble, being much larger on some plants than on others. Inside these nodules are great numbers of bacteria, which have the power of taking free nitrogen

Roots of soy bean plants, showing nodules.

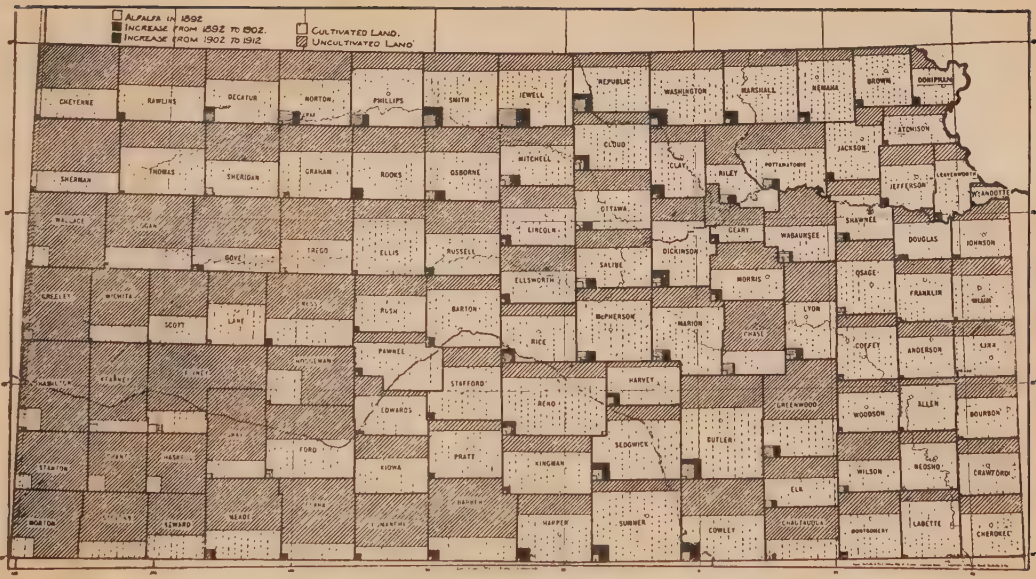
from the air in the soil and combining it with other elements in such a way that it can be used as food by the legumes. This is of great advantage to the legumes in that they need not depend on the soil for all the nitrogen that they require. These bacteria will not grow well in soil deficient in lime. It is necessary to add lime to some soils before legumes will grow in them.

Inoculation. The kinds of bacteria differ somewhat on different kinds of legumes, and frequently it is necessary to get some of the proper kind of bacteria into a soil before alfalfa or cowpeas, for example, will grow well. This process of introducing bacteria into the soil is called inoculation. A field may be inoculated by bringing earth from a field in which the particular legume has grown, and mixing this earth into the field; or the bacteria may be added to the moistened seed and so planted with it. Many fields are inoculated by the wind, by plows, by manure, and by other means.

How Legumes Differ. Legumes are annuals, as peas and beans; biennials, as sweet clover; or perennials, as alfalfa. They may be grown for their seed, as are peas and beans, or they may be grown chiefly as forage crops, as are alfalfa and the clovers. Some, such as the cowpea and the soy bean, are used in both ways to a slight extent. Besides the important legumes discussed in this chapter, many others are of importance elsewhere, such as Canada field peas, grown for stock feed in Canada and the northern United States, and others grown in the South.

ALFALFA

Alfalfa, which is sometimes called lucerne, was first grown in the United States more than one hundred years ago, but was not at that time considered of much value. It was introduced into California and the southwestern



A map of Kansas showing the proportion of cultivated and uncultivated land in each county, and the proportion of the county in alfalfa in 1892, 1902, and 1912.

states about 1850, and has slowly spread over the country since that time, until it is now grown more or less in all the states. Kansas grows more alfalfa than does any other state, but the acreage of alfalfa in Kansas is only one-half what it profitably could be.

Habits of Growth. Alfalfa lives for several years, and is therefore called a perennial plant. It begins growth in the spring by sending out from the top of the root a number of stems. Each stem branches several times. The stems grow from one to three feet high. The flowers grow out from the point where the leaf joins the stem. Each plant has one large root that runs deep into the ground and that has few small branches. The long roots obtain water from all parts of the soil into which they penetrate. Alfalfa roots grow deeper than the roots of most plants, and can therefore often obtain water which is beyond the reach of shallower-rooted crops.

Conditions of Growth. Alfalfa requires a deep, well-drained soil. It will not live for any great length of time in a wet soil. It will stand overflow for several days, if the plants are not covered with mud, and if the water drains off rapidly, but wet lands must be drained by tile drains or open ditches before alfalfa can be grown upon them. One cause for the failure of alfalfa in parts of eastern Kansas is the poorly drained condition of the soil. If water stands in post holes for five or six days after a heavy rain, the soil is too wet for this crop.

Alfalfa will not grow on a soil deficient in lime. When planted on a soil in this condition it either produces small, yellow, sickly-looking plants, or does not grow at all. Such a soil should be limed before alfalfa is sown.

Some soils are so poor that they will not grow a profitable crop of corn or wheat, yet alfalfa is expected to grow

upon them. Alfalfa will not do its best on poor soils. They must be enriched with barnyard manure before being seeded, and thin applications of manure in the years following will be beneficial.

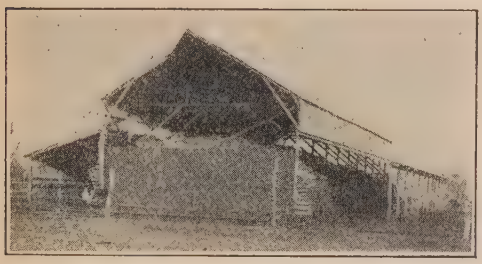
Alfalfa grows well in regions too dry for tame grasses and clovers, and the crop is therefore important in most parts of Kansas. Even in states farther east, where tame grasses and clovers grow well, alfalfa is highly valued because it produces three or four cuttings in a season, while the other hay crops produce but one or two.

Alfalfa plants, showing the long taproots.

Varieties. There are several varieties of alfalfa, just as there are varieties of corn or wheat. The different varieties look very much alike, but vary in resistance to cold, in the amount of hay produced, and in the uprightness of the stalks. If grown as far north as Kansas, some varieties freeze out badly in the average winter. These are valuable only in the southern states. Other varieties are highly resistant to cold, and are valuable in northern states, such as Minnesota and Wisconsin. When grown in Kansas the northern varieties do not yield so much hay as does the home-grown, or American, alfalfa. The American alfalfa is the variety

first brought to California from Chile, and has been grown in Kansas so long that it is well adapted to Kansas conditions.

The Seed Bed. Success in starting alfalfa depends largely upon the preparation of the seed bed. A poor seed bed has been responsible for more failures with this crop than has any other one factor, except the weather. A good seed bed is a firm, well-settled soil with the surface mellow and finely pulverized as deep as the seed is to be sown. A firm seed bed of this character allows free movement of the capillary water from the subsoil, and at the same time furnishes the plant with the proper root hold. Besides being mellow and firm at planting time, the seed bed should contain ample moisture and available plant food. Time is required to store moisture and to liberate plant food; hence, the earlier the preparation of the seed bed can begin, the better will be the results.

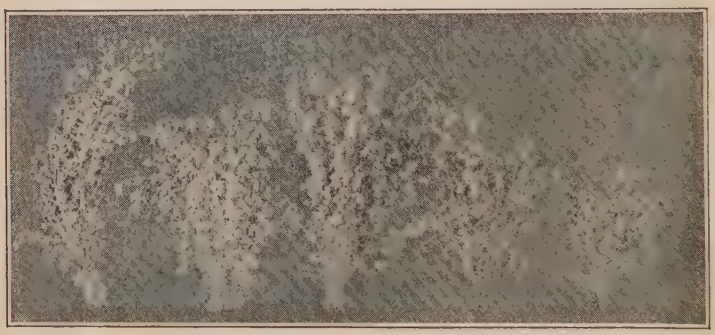


An alfalfa hay barn and feed shed combined.

A very satisfactory bed for fall seeding may be prepared by shallow-plowing wheat or spring-grain stubble immediately after harvest, and working the ground sufficiently thereafter to kill all weeds and maintain the soil in good tilth until seeding time. The plowing should be as shallow as possible to cover the stubble well; otherwise, unless heavy rains come between plowing and planting time, it will be impossible to establish a firm seed bed. It takes several months and considerable rainfall to re-firm a

deeply plowed soil. Where it is advisable to loosen the soil to a considerable depth before seeding, the ground should be plowed deeply for the crop preceding alfalfa. A clean field of wheat, oats, or barley stubble can be put into good seed bed condition by thoroughly disking the stubble under soon after the crop has been taken from the land, and then keeping it well tilled until planting time. Likewise, in favorable seasons, alfalfa may be successfully fall-seeded after a crop of cowpeas, flax, or millet, by disking the ground thoroughly as soon as possible after the crop is removed, and by keeping it well worked until time to plant.

When alfalfa is to be seeded in the spring, the best seed bed can be prepared by plowing the ground the fall pre-



Five types of alfalfa in one cutting. Observe the variation in manner of growth.

ceding, leaving it rough over winter, and then working it into good condition with the disk and the harrow. A fair seed bed can often be prepared in the spring simply by disking corn-stubble land, especially where the corn was kept well cultivated and free from weeds during its growth. When such land can not be fall-plowed, this method is to be preferred to spring plowing.

The Time and Manner of Seeding. Alfalfa may be

sown in the fall or the spring. Fall seeding is usually most successful in the eastern half of Kansas. Alfalfa sown in the early fall becomes fairly well established before winter, starts ahead of the weeds the next spring, and in the summer will produce more hay than if the crop had been spring-sown. Spring-sown alfalfa is often choked by weeds, and when a stand is secured an entire year is required to start the crop. In western Kansas, where the fall is usually too dry to start alfalfa, and where grasshoppers are troublesome, the crop is most successfully started by seeding in the spring. Spring seeding should not be done until the soil is moist and in good condition to germinate the seed, and until danger of blowing is past.

A good type of drill for seeding alfalfa and clover.

The seed may be sown broadcast or drilled. When sown broadcast it should be covered from half an inch to an inch deep by harrowing. When planted with a drill, the seeds are all covered to the same depth, so that all have the same chance to start. The drill covers every seed, while the harrow leaves some seeds on top which either do not sprout at all or dry out and die after they start. Drilling also saves several pounds of seed to the acre. There is, however, danger of covering the seed too deep with a drill, and for this reason many prefer the broadcasting method.

An alfalfa cultivator.

The Rate of Seeding. The best rate at which to sow alfalfa varies according to the locality in which it is sown.

In the central and the eastern part of Kansas, where rainfall is ample, fifteen to twenty pounds of seed should be sown, although in a good seed bed, where the plants will germinate and grow quickly, one-half this quantity of seed will produce sufficient plants to cover the ground thoroughly. In western Kansas, where the rainfall is not sufficient to support a heavy growth of alfalfa, light seeding will produce best results. From eight to twelve pounds an acre will be sufficient. On the uplands even less than this should be sown.

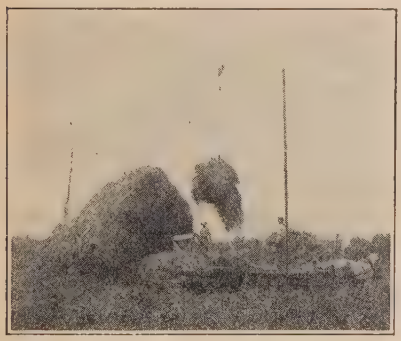
Treatment After Seeding. Spring-seeded alfalfa should be mowed, with the sickle bar set high, several times during the summer, to keep down weeds. Fall-sown alfalfa will usually produce good hay the first summer. Alfalfa is ordinarily not cultivated the first summer of its growth, but from the second summer on at least one cultivation a season will usually be profitable. Light applications of manure in the winter are very profitable, and in some regions commercial fertilizers supplying only phosphorus will give good returns.

An alfalfa field on April 14. Manured on the left, unmanured on the right.

The Time for Harvesting. Alfalfa is usually cut for hay when about one-tenth of the blossoms are open. For all kinds of farm animals except horses, the best hay is made by cutting it at about this stage of development. When cut for horse feed the crop may better be permitted to stand until it is in full bloom. It is not always

possible to judge, from the stage of blossoming, the proper time to cut the hay crop to secure the maximum production and at the same time the best quality of hay. It is usually best to be governed by the development of new shoots at the crown of the plant. When new shoots reach a growth of an inch or two the hay should be cut.

Harvesting. There are several methods of haymaking commonly followed in harvesting alfalfa. A good practice is to cut the alfalfa in the morning of a clear day, rake it into windrows later in the afternoon, bunch it with a rake the next morning, and put the hay into the mow or stack by the second afternoon. Care must be used not to shatter the leaves, for they contain the greater part of the food material. It is not necessary in Kansas to attempt to cure hay in the cock unless rain is probable. The average yield of hay for the whole state is two tons an acre. Many farmers, however, harvest four or five tons in a good season.



Stacking alfalfa on a Kansas farm.

Seed Production. The second crop of alfalfa is often harvested for seed instead of for hay. In the drier parts of the country alfalfa is sometimes planted in rows and cultivated for seed production. Great care is necessary in handling the seed crop, for it is very easy to break off the seed pods by rough handling. Yields of from two to five bushels an acre are common.

The Effect of Alfalfa on the Land. Alfalfa is generally regarded as a soil-improving crop, and when allowed to stand only five or six years it does enrich the soil. This result is more evident, however, in the states of heavy rainfall than in Kansas. When alfalfa stands are allowed to remain ten or fifteen years in central and western Kansas, succeeding crops do not grow properly, partly because the alfalfa roots have exhausted the subsoil of water. In these regions kafir is a better crop to follow alfalfa than is corn, because kafir grows well in a drier soil. For the best results from alfalfa the hay should be fed on the farm, and the manure produced by the stock should be carefully saved and returned to the soil.

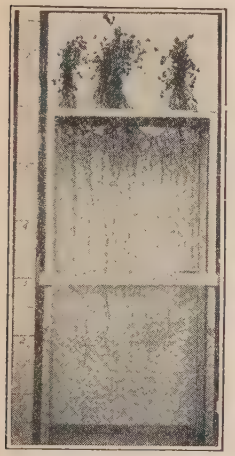
CLOVERS

The clovers constitute an important group of legumes. There are several varieties, varying in habits of growth and in usefulness. The different varieties are adapted to different conditions and uses. There are annual, biennial, and perennial varieties. All have very fibrous roots, which extend comparatively deep into the soil. The taller varieties are cut for hay, and furnish a feed rich in protein. Other varieties are prized for pasture.

Since they require considerable moisture, clovers are more widely grown in the states farther east than in Kansas. Clovers can be grown profitably only in the eastern fourth of the state. Clovers will not grow on soil deficient in lime, and will do best if the bacteria particularly suited to the given variety are present. Clovers are seeded in a manner similar to that employed in sowing grass.

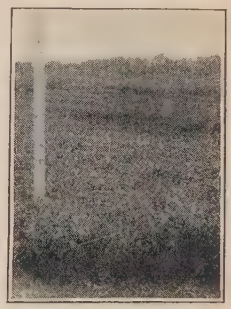
Red Clover. Red clover, also called little red, medium red, and common clover, is a biennial. It may be seeded

in fall or in spring. Fall seedings very frequently winterkill, and late freezing frequently kills the stand from spring seedings. Spring seedings with small grain usually furnish good pasture the following fall. In the second summer the plants will bloom when from eighteen to thirty inches high, and if cut then will make a valuable hay. There usually follows a second growth which may be used for pasture or cut for hay or seed. Red clover and timothy are frequently sown together, their yield and their feeding value being thereby increased.



Medium red clover, showing the root development in the second year of growth.

Crimson Clover. Crimson clover is an annual which is seeded in August or September to furnish winter and early spring pasture, to serve as a cover crop, or to be plowed under for a green manure. The plants mature in the spring and may be cut for hay, but frequently rains at this season make harvesting difficult. Crimson clover is not well adapted to Kansas conditions.



A plot of red clover making a good growth of excellent hay.

Mammoth Clover. Mammoth clover, also known as cow clover, can not be easily distinguished from red clover except by its greater size and by the fact that it seldom makes more than one crop of hay a season. The roots are longer, and the plant seems to stand dry weather better than does the ordinary

red clover. The yields of hay from the two varieties are practically the same.

Alsike Clover. Alsike clover will grow well in lands so wet that other clovers die out. Its root system is more fibrous, and the stems are finer than in other varieties. Because the hay is finer, it is considered better for sheep than that of the other clovers. A little alsike mixed with grass and other clover seed will provide a cover for the wet or boggy spots.

A red clover plant.

Sweet Clover. Sweet clover is not closely related to the clovers already mentioned, but is a legume of considerable importance. It is a biennial plant, which in the first year seldom flowers, but grows from eighteen to thirty inches tall. It dies to the ground the first winter. In the second spring, new shoots spring up like those of alfalfa. These reach a height of from five to seven feet if not cut for hay or pastured. It stands pasturing well. If cut for hay, it must be harvested before the blossoms come out, because after blossoming the plants rapidly

Sweet clover ready to be plowed under for green manure.

become woody. If cut when in full bloom, the plants usually die. Owing to its bitter taste, stock must acquire an appetite for it, but, having once acquired the taste, they eat it readily. It makes a hay of fair quality. If the crop is harvested at the proper time, another growth starts from the stubs still remaining, and three cuttings can be obtained in the ordinary season.

Sweet clover has grown wild along roadways and ditches for many years. It is one of our most valuable plants for improving poor or gravelly soils. Its value as a hay and pasture crop has been learned only in recent years, and many persons at present are slow to try it. Sweet clover will not grow on acid soils, but does well under practically all other conditions. It will grow in sand, in overflow land, or on the steepest and rockiest of hillsides, and in the drier parts of the state. There are a white variety and a yellow variety. The white variety is usually preferred.

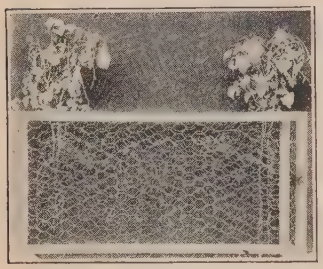
Other Clovers. Other clovers of less importance are white clover, used in lawns and pastures of Kentucky blue grass, bur clover, and lespedeza, or Japan clover.

COWPEAS

The cowpea plant first came to the United States about 1734, when it was brought into the Oglethorpe colony in Georgia. It has been grown for many years in the southern states for hay, seed, pasture, and green manure. Only in recent years have attempts been made to grow it in the northern states.

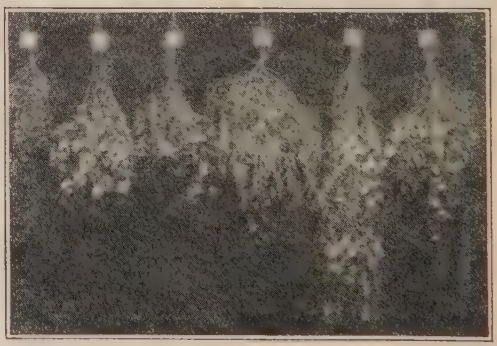
The cowpea is an annual legume producing stems about two feet high. Some varieties have vines several feet in length, while others have scarcely any vines. The leaves are shiny and large, and the blossoms are small. After blooming starts there are blossoms and pods in all stages of development until the plant dies or is killed by frost.

The cowpea seed resembles the ordinary garden bean. The pods are from six to twelve inches in length. The root system consists of a taproot from which many branch roots are sent out. They extend deep into the soil, the plant being one of the deepest-rooted annuals. The roots bear nodules in the same manner as alfalfa, but cowpea nodules are much larger than alfalfa nodules.



Cowpeas, showing the development of the roots.

Conditions of Growth. Cowpeas are adapted for growth on a wide variety of soils. They make their best growth on a rich loam, well supplied with plant food, but on poor soils will do very well in comparison with other plants. Grown on poor soil, cowpeas tend more to seed production, while on rich soils they produce more vine. They are grown successfully in states farther north than Kansas, although earlier-maturing varieties must then be used. The time required for maturity varies from seventy-five to one hundred and twenty days. Cowpeas do well on nearly all soils in Kansas if supplied with sufficient moisture.



Cowpeas and soy beans, showing variation in manner of growth. Three varieties of cowpeas on the left; three varieties of soy beans on the right.

They do not seem to need inoculation in this state. Soils of medium fertility are best. For drier regions the early-maturing varieties should be chosen.

Seed-bed Preparation. As with most other crops, we can not expect cowpeas to do their best unless we prepare the ground well and are sure there is a fair amount of plant food and moisture in it. Since they are planted late, spring plowing is generally practiced when they form the main crop of the season. Plowing is frequently done early, and the ground is cultivated several times to kill weeds and store moisture.

Cowpeas planted in corn.

Cowpeas are often seeded as a catch crop after wheat. In this case the stubble is disked as soon as possible after the wheat is removed. Sometimes they are seeded with a disk drill without previous working of the soil, if the soil is clean and not baked. They may be seeded in corn or kafir on bottom land either at the time of planting or at the last cultivation.

Seeding. When cowpeas are to be used as the only crop on the field in a season, the seed is planted about the

last week in May or the first week in June. If they are seeded in rows, planting may be done with a corn planter, or a wheat drill may be used, provided that some of the holes of the drill are closed. They may also be seeded broadcast or in rows six to ten inches apart with a grain drill. Broadcast or close-row seeding produces best results when about one bushel of seed is sown to the acre.

A field of cowpeas grown for seed.

Cultivation. Where cowpeas are planted in rows, they can be cultivated and the weeds kept down. Where they are not in rows, weeds sometimes grow up so thick that they spoil the hay crop. Cultivating is done with the same tools and in the same manner as in the case of corn. It is best not to cultivate after the blossoms appear, for cultivation keeps the vines growing and vine growth is not wanted after the plants begin to bloom.

Harvesting. Cowpea hay is full of coarse stems which are very woody if allowed to get too ripe. It should therefore be harvested for hay when the pods first begin to turn yellow. When harvested for seed cowpeas may be cut when most of the pods are ripe. Harvesting is done with a mower, and the plants are allowed to lie in small piles in the field for several days to cure. The coarse stems of the cowpea dry out more slowly than fine-stemmed grass or alfalfa. Therefore cowpea hay must be well cured before it is stacked or stored in the barn, else the hay is likely to spoil or to take fire.

Cowpeas for Green Manuring. In Kansas cowpeas are more important as a green manuring crop than as a hay or seed crop. The plants are valuable sources of humus and nitrogen because of the short time required to mature, the luxuriant growth, and hence large amount of nitrogen gathered from the air. For green manuring, cowpeas should be planted on wheat or oats stubble which was disked immediately after harvesting. The crop should be plowed under in the fall, and the ground planted to corn or sorghum the following year.

SOY BEANS

The soy bean plant is similar to the cowpea in the time and the manner of growth. It has not so many vines, however, and the stem, the leaves, and the pods are covered

Soy beans in rows at the Kansas Experiment Station.

with tiny hairs. The pods are only one or two inches long. The bean itself looks like a garden pea, and the colors range from cream to black.

Soy beans will stand more drouth than cowpeas, and also will stand more wet weather than cowpeas or corn.

On the poorest soils cowpeas will probably be more profitable than soy beans. Where used for hay or where plowed under for green manure, cowpeas and soy beans produce practically the same effect on the land. Inoculation is necessary for the best results with soy beans.

The feeding value of soy bean and that of cowpea hay or pasture are practically the same. The two are often sown in a mixture of two parts of soy beans to one part of cowpeas, the soy beans serving to hold up the cowpea vines, thus making them easier to handle for hay.

Soy beans are more profitable as a grain crop than are cowpeas, twenty to twenty-five bushels an acre of soy beans being obtainable as against only twelve to fifteen bushels of cowpeas.

The Value of Cowpeas and Soy Beans. As the need of a legume adapted for use in short rotations is felt more and more, both these crops, and especially cowpeas, will be more generally grown in Kansas. They produce hay and grain that rank high among farm feeds. They do this, moreover, in a short period of time, and when harvested leave the ground in excellent condition for the next crop.

QUESTIONS

1. Give all the reasons you can for the importance of legumes on the farm.

2. How do legumes gather nitrogen from the air? Why is their ability to do this important?

3. What is meant by inoculation? How may a field be inoculated?

4. Under what conditions of soil moisture will alfalfa fail? When will it do best? When better than most crops? Why?

5. How does lack of lime affect alfalfa plants? How can the effect be remedied?

6. Describe a good seed bed for alfalfa. How may it be secured?

7. When is the proper time of the year to sow alfalfa? Why?

8. How much seed should one sow to the acre? How does this amount vary?

9. When should alfalfa be cut for hay? Why?

10. Name the varieties of clover and tell briefly how they differ.

11. What clover grows best in wet soils?

12. Describe sweet clover. How does it differ in usefulness, conditions of growth, and other details, from other clovers?

13. What special advantages have cowpeas as a crop? What different uses are made of them?

14. How are cowpeas planted? How are they harvested for hay? for seed?

15. How do soy beans differ from cowpeas in appearance, adaptation to Kansas conditions, extent to which used?

CHAPTER XII

GRASSES

We have already studied corn, wheat, oats, barley and rye, five important members of the grass family. These grasses, known as cereals, are grown chiefly for their seed, which is called grain. They are valuable for food because of the quantity of starch, oil, and protein stored in the grain.

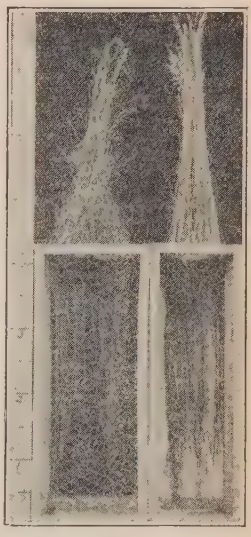
The other important group of cultivated grasses is made up of those which are valuable because of the food stored in their stems and leaves. These are grown for hay or pasture, and are the ones usually thought of when grasses are mentioned. In this chapter we shall understand the word "grasses" to refer only to these plants.

For convenience we may divide the grasses grown in this state into native, or wild prairie, grasses, and tame grasses.

Native Grasses. The native grasses are classified as tall and short. The tall grasses grow chiefly in the eastern half of Kansas, and include big bluestem, little bluestem, tall grama, wild oats, and slough grasses. They have long roots that grow deep into the soil, and to grow well must have considerable rain. The tall native grasses are both pastured and cut for hay. The short grasses are mainly buffalo grass and grama grass, and grow, for the most part, in western Kansas. These short native grasses furnish excellent pasture for live stock, but do not grow tall enough to be cut for hay. When the native sod is

plowed and the grasses are killed, it requires several years to reëstablish a good sod.

Where too much stock is pastured on the land, the grasses gradually die out, and weeds take their place. Grass weakened by excessive pasturing can be improved by light pasturing for two or three years, and by disking of the sod so as to encourage new roots and stems to grow.



Grasses have dense fibrous root systems.

Tame Grasses. Tame grasses are so called because they have been grown and improved by man. Most of the tame grasses were brought to America from Europe, where they had been grown for centuries.

West of the Missouri river, tame grasses are not commonly grown. In Kansas they are limited almost entirely to the eastern third of the state.

After tame grasses have grown in a drier country for several years, they seem to become able to live there better than at first, and it is hoped that some of them can be changed in this way so that they will grow well in the drier parts of the state. One reason that the tame grasses are so important, aside from their larger yield of hay, is that they produce enough seed to be harvested and sold. Because the native grasses do not produce enough seed to be harvested profitably, they can not be reseeded.

Kinds of Tame Grasses. The tame grasses may be classified as pasture grasses and hay grasses. The pasture

grasses must form a dense sod that will stand tramping by animals. They should grow early in the spring to furnish spring pasture, and should keep growing all through the summer and the fall till cold weather comes. Not all of them will grow vigorously all this time. Because the time of vigorous growth varies with different grasses, a mixture is often best for pastures. Pasture grasses need not grow tall. The hay grasses need not come on so early or grow so late, for when they are once cut they have served their

A native hillside pasture in good condition.

main purpose. They are more valuable, however, if they do grow early, for they may then be pastured for a time and later allowed to grow up for hay. They are still more

valuable if they grow up again after being cut, and furnish fall pasture.

TAME PASTURE GRASSES

Kentucky Blue Grass. Kentucky blue grass is the great pasture grass of the eastern and central states. It forms a dense sod and grows early in the spring and late in the fall, but dies down during the hot summer weather. It furnishes much pasture, and if allowed to grow up reaches a height of eighteen to twenty-four inches and makes fair hay. On the glacial soil of northeastern Kansas and the limestone soils of southeastern Kansas it grows naturally in all pastures and on the hillsides. Farther west it does best in the bottoms. White clover usually grows with blue grass, and helps to make a good sod. Where it does not burn out in summer, blue grass is well adapted to lawns.

Weeds in a native hillside pasture. The grass has been killed by too close grazing and weeds have taken the place of the grass.

Bermuda Grass. Bermuda grass has not yet been able to live through the coldest winters of central and northern

Kansas. It does well only in the most southern counties. It is a grass adapted to the southern states, but makes good lawns in southeastern Kansas, and may in time be used for pasture. The hardiness of the plant is increasing, and before long it may be able to live through the hardest winters. It forms a dense sod, and makes an excellent pasture. It stands dry, hot weather better than any other grass, and after such weather has the ability to spring up very quickly when a good rain falls. It is propagated by scattering small tufts of sod three or four feet apart each way on well-prepared land. In favorable seasons a good sod is formed.

Kentucky blue grass. This grass makes a thick, fine growth, and for this reason forms excellent pasture in eastern Kansas.

Mixtures for Pastures. Mixtures of the taller-growing grasses used for hay are also very valuable for pastures. Some of the hay grasses, when sown alone, do not make a good sod that stands tramping well, but when mixed with others make excellent pastures. One of the best combinations of grasses for pasture in eastern Kansas comprises meadow fescue, ten pounds; orchard grass, ten pounds; brome grass, eight pounds; and medium red clover, six pounds an acre. For central Kansas a good combination consists of brome grass, ten pounds; orchard grass, twelve pounds; western rye grass, eight pounds; and alfalfa or sweet clover, six pounds an acre. For western Kansas the following combination is desirable: brome grass,

Meadow fescue, or English blue grass.

fourteen pounds; western rye grass, eight pounds, or tall meadow oat grass, twelve pounds; and sweet clover, ten pounds an acre.

TAME GRASSES FOR HAY

Timothy. Timothy is the standard hay grass of America. It is regarded as the best hay for horses, although not so nutritious as alfalfa or the clovers. It grows to a height of from two to four feet, and forms a rather coarse, stemmy hay. In Kansas timothy does best on bottom land that is fairly moist and fertile, but will not stand wet soils. It does not furnish much pasture after the hay is cut, and often burns out badly in the hot weather following cutting. For cattle and sheep a better quality of hay is made from a mixture of timothy and red clover.

Timothy.

Orchard Grass. Orchard grass stands more drouth than meadow fescue or Kentucky blue grass, but not so much as brome grass. It does very well in eastern Kansas, where, because of its early spring growth, it is often used in mixtures for pastures. It grows in clumps, and does not make a smooth sod. It grows well in shade. Orchard grass makes good hay when cut early, but the large stems soon become coarse if allowed to stand too long before being cut.

Meadow Fescue. Meadow fescue is commonly called

English blue grass. It does best south of the Kansas river and for about a hundred miles west of the eastern border of the state. This region produces nearly all the English blue-grass seed grown in the United States. This grass grows best on fertile bottom land, but does well on uplands in the region mentioned. It is valuable for pasture, but not so good for hay as timothy.

Orchard grass.

Brome Grass. Brome grass makes a good hay, but is essentially a pasture grass. The stand at first may be thin, but it rapidly makes a firm sod, and later often needs disking to relieve its sod-bound condition. It stands the dry conditions of the plains farther north, where only from twelve to fifteen inches of rain falls in the season. It is usually sown by hand, as the seeds are too large to pass readily through a seeder.

Western Rye Grass. Western rye grass is a native American grass. It excels brome grass in withstanding cold and drouth, but does not do well in hot summers. It starts late in the spring, and ceases growth early in the autumn, but makes a good late spring and summer pasture.

Redtop. Redtop is well adapted to poor soils and soils that are not well drained. It is of much value in southeastern Kansas. It is not so palatable as timothy for hay or pasture.

Other Tame Grasses. Other tame grasses of more or less importance are: tall meadow oat-grass, Italian rye grass, perennial rye grass, meadow foxtail, reed canary grass. Owing to the danger of its spreading and becoming a pest, the seed of Johnson grass can not legally be sold in Kansas. This grass is a large producer in southern states.

A field of timothy.

Seeding. Most grass seeds are very small, and therefore great care must be taken in the preparation of the seed bed. It must be firm beneath, and have finely pulverized soil on top to cover the seed. Fall-plowed land is best for spring-seeded grass. If the grass is seeded in the fall, the land should have had time to become firm, hence plowing should be done in July. The seed should be covered about half an inch deep, and sufficient moisture should be in the soil to sprout the seed and keep the young plants growing. It is best to wait if it is dry, and sow the seed as soon after a rain as possible. Seeding in a nurse crop of wheat, oats, or other grain is usually not advisable.

QUESTIONS

1. What are the points of resemblance in the plants belonging to the group called grasses?

2. What is the difference in the use of the tall native grasses and that of the short native grasses? Name two grasses of each kind.

3. What are tame grasses? Where did most of them come from? What is the most important difference between tame and uncultivated grasses?

4. In what part of Kansas is the tame grass crop of most importance? Why are tame grasses not more generally grown in other parts of the state?

5. How do hay grasses and pasture grasses differ in growth?

6. What is the most important pasture grass in the eastern states? Where does it grow best in Kansas?

7. To what regions is Bermuda grass native? Describe its manner of growth. Why is it not more generally grown in Kansas?

8. What is the standard hay grass of America? Why? In what part of Kansas is it grown? Why is it not more generally grown in this state?

9. What are the good qualities of orchard grass? What are its disadvantages?

10. Where is most of the meadow fescue seed produced in the United States grown?

11. To what conditions and uses is brome grass well adapted?

12. Where is redtop grown?

13. When and how should one prepare the seed bed for fall seeding of grasses?

14. Make a list of all the tame grasses, their chief uses, and the regions in which they are commonly grown.

CHAPTER XIII

HOW PLANTS AND ANIMALS ARE IMPROVED

Wild plants and animals are seldom exactly suitable for man's use, although they are generally well suited to the wild condition. Plants and animals are domesticated in order that man may have a food supply that will be certain and always ready. Most of the domesticated food plants have been in cultivation for thousands of years. Wheat, rice, barley, and sorghum; apples, pears, and peaches; cabbage, turnips, and onions—to name only a few examples—have been in cultivation for at least four thousand years. Food plants have been cultivated longer than forage plants.

Variation. Plants vary under cultivation. Whenever a plant is taken into cultivation it seems to break up into races and varieties. Let us take, as an example, the cabbage and its relatives. We have cabbage itself, in which there is a short stem with a clump of leaves folded into a ball; savoy cabbage, with finely crinkled leaves; cauliflower, in which the plant consists of a short, thickened flower head, resting in a nest of leaves. There is Brussels sprouts, which has a tall stem covered with little cabbage heads borne along its length. There is kohl-rabi, in which the stem becomes a thick, solid ball, like a turnip above the ground. Finally, there is kale, a plant in which the leaves grow up like lettuce, without a visible stem. All these very different kinds of vegetables came originally from the wild cabbage, a plant native to the coast of

Plants may be greatly modified in habits of growth by selection. All these different plants have been produced by man from wild cabbage: 1, wild cabbage; 2, kale; 3, cauliflower; 4, kohl-rabi; 5, cabbage.

Europe from Denmark to southern France. In these various races we may see that man has developed different parts of the plant for his own use as food. In each race there are many cultivated varieties. For example, there are at least sixty varieties of white cabbage, nearly twenty of red cabbage, thirty of savoy cabbage, thirty of cauliflower, ten of Brussels sprouts, twenty of kohl-rabi, and thirty-five of kale — in all nearly two hundred of what are called varieties, belonging to five different races that have all come from the wild cabbage.

Wheat is one of the oldest of cultivated plants, and there are to-day perhaps five hundred varieties, some of which have red while some have white kernels; some have hard while some have soft grains; some are bearded and some beardless; some have hairy while some have smooth chaff. Indian corn, which is a very ancient grain of American origin, has hundreds of varieties, divided among six principal races; namely, the dent, flint, sweet, pop, soft, and podded groups of corn. Of the most useful race—the dent corn—there are, of course, the most varieties. When corn breeding began in America the varieties of dent corn then grown would not mature in the far northern part of the country. Corn growing was unknown in the far northern part of the Middle West. Now Minnesota and the Dakotas raise abundant crops of the ninety-day varieties of dent corn that have been developed within recent years.

At the beginning of the Christian era there were probably no more than a dozen varieties of cultivated apples. Now there are more than a thousand, adapted to a most remarkable variety of soils and locations.

Improving Plants by Selection. By selection, the tomato has been changed from a small fruit the size of a

cherry, believed by the people then living to be poisonous, to a large, smooth fruit which is now considered a table delicacy. We have seedless oranges, prunes, and raisin grapes formerly unknown. We have found varieties of wheat that are not attacked by rust, cowpeas not attacked by wilt, and other disease-resisting plants.

Branches from alfalfa plants having different kinds of leaves but growing in the same field.

Plant improvement has progressed more rapidly than ever before, because of man's increased knowledge. The search for plants capable of improvement now goes on in every civilized country, though it is constantly more difficult to find such plants that are not being used.

Breeding by Selection. There are two ways in which we have obtained these many kinds of improved plants: first, selection; second, crossing, or hybridization. To improve plants by selection, we may go into any field of either wild or cultivated plants, and find some that seem to be better than others. By saving the seeds of these and by planting them separately we may find that all the plants that come from these seeds are also better than the average, just as was the plant first selected. If we find this to be true, and if the plants "come true," as we say, then we know that we have a new and improved race of plants. In this way originated squarehead, white Victoria, and other varieties of wheat. The Concord grape came from a chance seedling which Ephraim Bull found on his Massachusetts farm. Schuyler Worden selected the first Worden grape from several seedlings of a Concord grape. Luther Burbank, while still a young man, sowed the seed from a potato seed ball, and from one of the plants gave us the Burbank potato.

Recently men have learned the value of these new and better varieties, and they look more carefully than ever before for plants that will be more valuable. Not only do they look in their own fields, gardens, and woods, but experts are sent to all countries of the world to try to get improved plants which can be grown at home. Several new plants are now grown here because of the work of these experts. Every farmer, and every boy and girl, however, can help to improve the plants on the home farm by careful selection of seed plants.

Improving Corn. Plant breeders have invented many effective methods of improving plants. One of the best of these is seen in the breeding of corn. If we go into any field of ordinary corn, we shall always find a few better-appearing plants, bearing better-looking ears. If we take

such ears from each of twenty-five plants and if we plant the seeds from each ear separately in a long row, we shall find, if we harvest each row separately, that there will be many striking differences in the yield of the different rows. If we now discard the seed from all the poorer rows, and plant only the seed from the best rows, we have taken the first step in corn improvement. We may now plant our improved corn in a block far enough from other corn so that there will be no danger of cross-pollination, and save for seed ears the best produced in this block. Repeating this method year after year insures steady improvement. Hildreth, Kansas Sunflower, and Pride of Saline are among the varieties of corn which have been originated in Kansas simply by selection.

Striped corn (grown as an ornament), which bears an ear at each joint, and ordinary field corn, which bears only one or two ears. The latter has been developed by many years of selection.

Improving Wheat. Wheat has been improved in a similar way. Since, however, the flowers of wheat are always self-pollinated, one year's selection is generally sufficient to obtain a pure kind of wheat.

In improving wheat, a good quality of ordinary wheat is planted in a nursery so that the plants are a short distance apart. One may then carefully examine each plant, and save in separate packages the seed of plants which seem to be superior. The following year the seed from each superior plant is sown in a row alone, and the yield of the various

rows is compared. The seed from the most promising row, or the most promising plant in a row, is saved and sown again. By repeating the process and increasing the amount of seed sown we may get a new variety in sufficient quantity to sow a whole field.

Before a new variety of wheat is generally adopted, it should be subjected to milling and baking tests so that we may know something of its flour- and bread-making qualities. This is not necessary in the case of corn, because it is used chiefly for animal food.

Alfalfa and timothy have been and are still being improved by propagation from selected plants. Alfalfa is selected for yield, uprightness, hardiness, and other characteristics.

In breeding by selection we must observe one rule: We must always begin with the seed of a single close-fertilized mother plant. This is called pure-line breeding, and is the method followed by the most successful plant breeders everywhere.

Breeding by Hybridization. By selection we obtain only that which nature has already provided. While we introduce new varieties in this way, we do not produce them. Nature produces them for us, and we simply find them, and save them, and grow them separately. By crossing plants, we may be able to originate many new kinds of plants. The plant which is produced by crossing two other plants is called a hybrid. Sometimes plant hybrids are sterile; that is, they will not produce fertile seed. It is very easy, for example, to cross wheat and rye, but it is very seldom that a hybrid between wheat and rye will itself bear seed. Plants are crossed, or hybridized, by taking the pollen from the anthers of the flower of one plant and putting it on the stigmas of the flower of another plant. This has been done by breeders with wheat, corn,

and all the other cereals, and with strawberries and all the bush fruits, such as blackberries and raspberries and the like, as well as with grapes, plums, apples, and many other fruits.

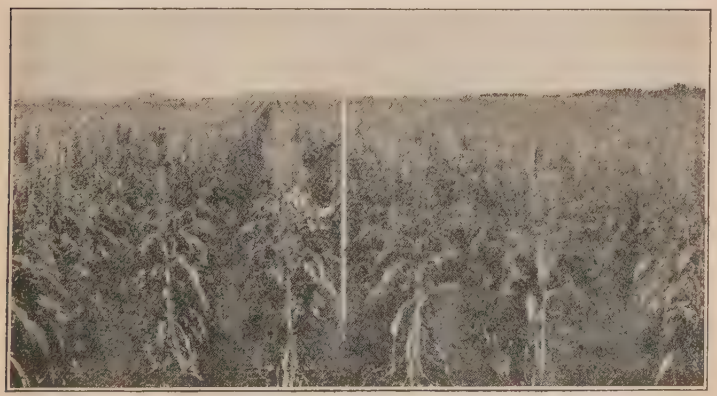
After plants have been crossed they generally will not continue to breed true, but will break up into different kinds in a way that is well understood. For instance, if we should cross a bearded wheat with a beardless wheat,

A field of sorghum unselected. The stand can be made uniform by selecting seeds from single plants and growing them pure.

all the hybrid wheat would be beardless; but in another year it would break up into bearded and beardless kinds. If we cross apples, peaches, or grapes, they will break up in the next generation in case we plant the seeds. When we get a hybrid of a perennial fruit tree, or of a grape vine, or of a berry plant, we do not, however, sow the seed of that plant to get new plants for the next year. We propagate the original plant by budding or grafting, or by making cuttings. In this way the original plant is multiplied a great many times. For example, McPike crossed the Niagara grape with the Worden grape, and obtained a new hybrid variety with enormous purple fruit which had a very thin skin and but one or two seeds to

the berry. This hybrid he propagated by cuttings until he obtained a large vineyard. Most garden strawberries are hybrids. If they were propagated by seeds they would soon break up and disappear. Strawberries, however, are propagated by runners, and all the plants that come from the runners are exactly like the original one.

Luther Burbank crossed the plum and apricot and produced the plumcot. He produced a hybrid walnut which grows much faster than the original walnut and produces a valuable hard wood. He also produced hybrid chestnut trees which bear at the age of a year and a half,



A pure stand of sorghum from selected heads. Notice the evenness of the stand.

and a hybrid cactus which is thornless and may be used for forage. By crossing the wild native sand cherries of South Dakota with standard plums, Professor Hansen produced fruits that are larger and better than the native wild fruits and that are perfectly hardy in the northern winters. Many other examples of such improvement might be given. We must keep in mind that this method is especially useful for garden fruits

that are perennial, and that can be multiplied by budding, by grafting, or by making cuttings.

Animal Improvement. Domestic animals, such as cattle, horses, sheep, and hogs, as well as such house animals as the dog and the cat, have all come from a few wild types of animals. For example, all our sixty or more domestic breeds of cattle probably came originally from two or three very ancient breeds that ran wild in the forests of Europe thousands of years ago. All our different breeds and kinds of horses probably came from three different wild breeds. The draft horses as well as the Iceland and Shetland ponies probably came from a dwarf wild horse that lived in the forests of Europe and browsed upon the small trees and shrubs. The race horses and roadsters came from the desert horses of Arabia and northeastern Africa or from a wild horse of the highlands of eastern Asia. The history of sheep and hogs is similar. Though there are many breeds to-day, they all came from a few kinds of wild ancestors.

What we have to learn from a study of all the different kinds of domestic animals is that man has found a great many variations springing up among those animals which he has taken in to domesticate, and that, by saving individuals that show this or that useful or interesting trait, he has succeeded in forming a great many breeds.

Pure Breeds. The breeds of domestic animals are now most of them fairly pure, and will generally breed true. For example, from a herd of Jerseys we always get Jersey cattle, and not Holsteins or Herefords. From a herd of Poland China hogs we never get Berkshires or Duroc-Jerseys. Within each breed, however, breeders are continually finding new variations. On the island of Jersey the breed is kept pure by a law which forbids the importation of any other than Jersey cattle except they be

slaughtered within twenty-four hours after landing. In this way the Jersey breed of cattle has been kept very pure and is very uniform. The American registered Jerseys have all come from the pure island stock. The American Jersey breed is, nevertheless, different from the original, being a larger animal, having heavier bones, and giving a higher yield of butter fat. Through having been bred chiefly for butter fat production, the American Jersey has gradually changed its form from that of the Jersey on the island, where more attention is paid to beauty of form, and less to utility. By being bred for beef production, a standard type of animal such as was never known wild has been produced through selection, yet all the breeds of beef animals have probably come from a single wild breed. The modern breeds of hogs, bred exclusively for the amount of meat they will produce, are so weak in the legs that they can not carry their own bodies to market; whereas the wild hog from which they came has a thin, long, rangy body, with long legs, and is thus capable of running and escaping its enemies. After a breed of domestic animal suited to some particular purpose is secured every effort is made to keep the breed pure by avoiding crossing with another breed, and record books are kept in which the history of registered animals of the different breeds is continued from generation to generation.

Crossing. Sometimes, however, selection alone will not give us all that we want in a domestic animal. Sometimes crossing is necessary, and so we have some herds of Texas Herefords that are being crossed with the zebus, the humped cattle of India, because the hybrids are immune to the attacks of the tick that carries the germ of Texas fever.

Crossing, or hybridization, is, for practical reasons, much more generally followed by plant breeders than by animal breeders, especially because plant hybrids can be propagated by budding, by grafting, by layering, by making cuttings. Animals are improved chiefly by selection of the more desirable individuals for breeding purposes.

QUESTIONS

1. What is variation in plants? Give examples of variation in cabbage and corn.

2. How are plants improved by selection? Give examples.

3. What is the best way of improving corn by selection?

4. How can wheat be improved?

5. What is a plant hybrid, and how is it obtained? What is the use of producing plant hybrids? Give examples of valuable plant hybrids.

6. What was the origin of our domestic cattle? What was the origin of our different breeds of horses?

7. How are pure breeds of stock obtained? Give examples of a pure breed.

8. Show how the pure breed of Jersey cattle has varied since coming to America.

CHAPTER XIV

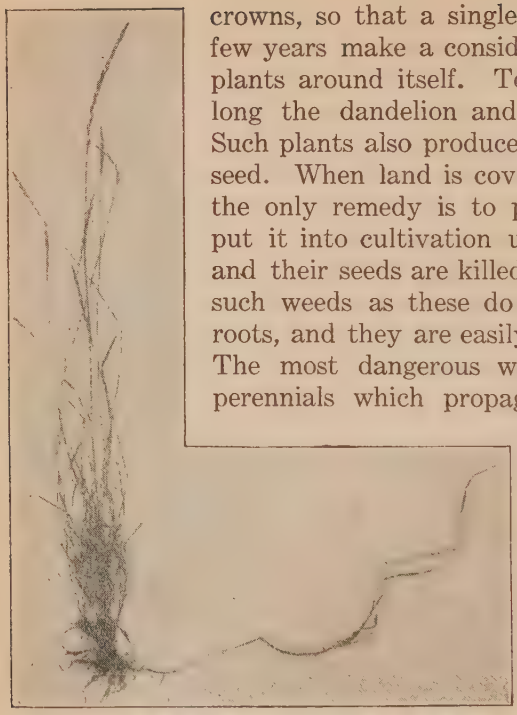
WEEDS

Weeds are plants out of place. Even harmless or useful plants may sometimes become weeds. Blue grass is a weed in a flower garden. Wild carrots, garden mustard, chicory, and salsify are all garden vegetables which sometimes grow wild and become weeds.

A head of cheat.

Classes of Weeds. Weeds may be divided into three general classes —annuals, biennials, and perennials. Annual weeds, such as pigweed, Jimson weed, wild lettuce, cocklebur, and weedy grasses like crab grass and foxtail, may usually be killed by clean cultivation. Biennial weeds, such as wild carrot and chicory, form roots the first year and produce their flowers and seeds the second year and die. Cutting these plants off below the crown will generally kill them. They should also be mowed before they go to seed. If this is done, no more plants will be produced from them, because the roots will not live the third year.

Perennial Weeds. Perennial weeds give the most trouble. These again may be classified according to their methods of propagation. Some kinds of perennials, which have a large taproot and crown, increase by forming new



Quack grass, a very troublesome and noxious weed. It propagates by means of underground stems which run horizontally through the soil.

crowns, so that a single plant will in a few years make a considerable patch of plants around itself. To this class belong the dandelion and the buckhorn. Such plants also produce a great deal of seed. When land is covered with them the only remedy is to plow it up and put it into cultivation until the weeds and their seeds are killed. Fortunately such weeds as these do not have deep roots, and they are easily plowed under. The most dangerous weeds are those perennials which propagate by means either of horizontal underground stems, or of horizontal propagating roots. Examples of the first kind are Johnson grass and quack grass; of the second, field bindweed, Canada thistle, and sow thistle. If it were possible to keep these weeds constantly cut below the surface so that not a leaf ever grew up to furnish food for the roots, they could finally be killed out, but this process is slow and expensive, since it requires many hours of hand labor. The best way of handling ground affected by these weeds in quantity is to plant the ground to some crop that will grow thick and partly smother the weeds. One method is to plant winter rye in the fall, plow it under in the spring, and follow

it with sorghum sown thick for hay; and to repeat the process until the weeds have been smothered. Where small patches of these perennial weeds are found starting in a field or garden they can be killed by the use of salt, which should be put on the ground at the rate of ten to fifteen tons to the acre. Of course, the ground will be made unfit for use for several years, but if the patches are small this will be less serious than to allow the weeds to spread. If salt is used, care should be taken to cover the ground about ten feet beyond what appears to be the outside edge of the weed patches, for the reason that many of these weeds spread very rapidly underground, and their roots or underground stems often grow far beyond what seems to be the edge of the patch above ground.

Bindweed in bloom.

Prickly wild lettuce.

The bindweed, which is the worst of all these weeds, and in fact one of the worst weeds in existence, is spreading in nearly every county in Kansas. It has been found that land infested with the bindweed can

be cleared by fencing young hogs, to the number of about twenty-five to the acre, upon the land thus infested. If the hogs are given light feed and thus compelled to eat the bindweed to the ground and root after the underground parts of the plant, the bindweed can be killed out in a couple of seasons. Of course, this method would not be practicable on a large scale. In general, the best method for killing the bindweed depends entirely upon circumstances—salt for small patches, hogs for somewhat larger patches, and smother crops for fields of considerable size.

Russian thistle, a troublesome annual weed which gets uprooted and rolls over the ground, scattering its seeds.

Barnyard Weeds. Weeds may again be classified according to the places in which they grow. There are weeds which are found as a rule only around barnyards and in very rich, extremely fertile soils. Such weeds are the Jimson weed, the bull nettle or horse-bur, the velvet leaf, and the burdock. These weeds are all easily killed by hoeing and clean cultivation where they occur in fields, and by mowing before they go to seed where they occur elsewhere.

Field and Garden Weeds. Field and garden weeds include a long list of our most common annual weeds, such as the pigweeds, water hemp, Black-eyed Susan, the horse weed, the sunflower, and in the western part of the state

the Russian thistle. Most of these have to be kept out by clean cultivation and hoeing. One of the weeds commonly found in fields and tame grass meadows is cheat.

Buckhorn, or English plantain, a troublesome weed in pastures.

Pasture Weeds. There are certain weeds most commonly known as pasture weeds. They generally appear in pastures which have been overstocked and in which the grass has been eaten down so closely that the weeds have an excellent opportunity to grow. Such weeds as pigweed, which have been referred to as barnyard weeds, are not usually found in pastures, because the ground is too dry. Among the most common pasture weeds are the wild verbena, the ironweed, and the bull thistle. These plants have very strong, tough roots, and are very difficult to eradicate. When found in the pasture they should be kept mowed to prevent their going to seed, and the land should be pastured lightly for two or three years until the grass is enabled to take the ground and drive the weeds out, which it will almost invariably do in time. The bull thistle is particularly difficult to eradicate because it grows from a fleshy tuberous root lying a couple of feet below the surface. If every thistle top is cut off below

the surface as soon as it appears this weed may, however, be eradicated.

Occasionally some of the native plants of the prairie become troublesome weeds. Among these are the western ragweed, a plant with narrow leaves, woolly on its under side, and with long horizontal propagating roots; the western fog fruit, a plant with deeply growing propagating roots and very narrow, wedge-shaped, light green leaves; the wild fescue grass, which is a small annual prairie grass with sharp-pointed seed heads, and which in dry seasons becomes abundant on the western prairies.

Bull thistle, or pasture thistle. It grows from a tuber. The first year it makes a few leaves and develops the tuber. The second year it sends up a flower top, and sends out roots which form new tubers.

There is no universal remedy for weeds. Each kind must be studied and fought by itself.

QUESTIONS

1. What is a weed? Give examples of different classes of weeds.
2. What is a perennial weed? Give examples of noxious perennial weeds. Why are they the most dangerous?
3. How can noxious perennial weeds be eradicated?
4. What do we mean by barnyard weeds? Give examples.
5. What is meant by field and garden weeds? Give examples.
6. What are examples of pasture weeds? How do weeds get into pastures?
7. How can weeds be kept out of pastures?

CHAPTER XV

SOIL FORMATION

The soil is the surface covering of the earth. It is composed of small pieces of rock and small particles of partly decayed plant material. A mass of material made up of rock particles alone would not be soil, but if this mass of rock particles were supplied with partly decayed plant material, moisture, and small organisms called bacteria, it would be capable of supporting plant growth, and would be a soil.

The rock particles make up the body, or mass, of the soil, and are called mineral matter. The plant material found in the soil is called organic matter. Organic matter is necessary in order that the soil may hold moisture, and is necessary also for supplying food for the bacteria that are essential to the growth of plants.

Soil and Subsoil. A distinction is usually made between the top or surface soil, which is commonly spoken of as the soil, and the subsoil, that portion immediately below the soil. The soil usually extends to the depth that the farmer plows, or a little farther, and is commonly darker in color and more open and porous than the subsoil. The more open condition of the soil is often due to the fact that it contains more organic matter than the subsoil, and also to the fact that many of the fine particles of the soil have been carried into the subsoil by water passing through the top layer.

In eastern Kansas, where the rainfall is heavy, the subsoil is usually less productive than the soil, because the

air has not come into contact with the lower layers of the soil sufficiently to liberate the plant foods. Deep plowing, which throws up a large amount of the subsoil at one time, usually results in decreased yields until the subsoil material becomes aired and mixed with organic matter.

In the drier parts of the state the soil and the subsoil may be thoroughly mixed without injurious results. A good subsoil is one that is deep and loose enough to hold large amounts of moisture, and to allow the roots of plants to penetrate to great depths. If the subsoil is composed

An ideal subsoil. This soil is deep and will furnish ample room for the deepest-rooted plants. It will also store an abundance of plant food and moisture.

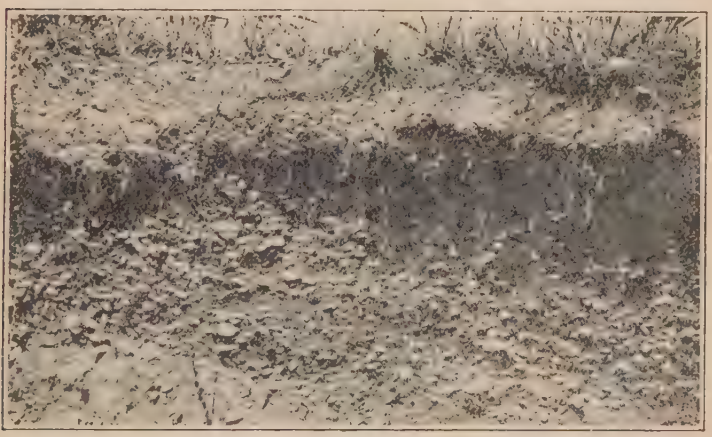
of very fine particles it is usually dense and compact, and will not permit ready entrance of the roots of plants. If, on the other hand, the subsoil is very open or is underlain by a bed of sand or gravel it will not hold sufficient moisture for the best growth of crops.

SOIL FORMATION

The earth is supposed to have been at one time a solid crust of rock. The soil was formed from this crust by the

action of water, air, ice, heat, cold, plants, and animals. These agencies have been constantly at work breaking up and wearing away the rock mass and carrying the finer material thus formed from mountains and hills into the valleys.

The Action of Water. Water acts upon rocks in two ways. First, it grinds up the rock; this process is called mechanical action. Second, it dissolves parts of the rock; this process is called chemical action. The mechanical action of water in forming soil takes place along every



A poor subsoil. The layer of gravel just below the surface soil prevents plant roots from growing downward, contains very little plant food, and allows the soil water to flow away.

stream. As water falls upon rocks and flows over them it grinds away the rock mass and carries the small particles of soil thus formed, down the stream to lower levels.

The chemical action of water in breaking up rock and forming soil is also great. Many of the particles which make up the rock are more or less soluble in water, and especially in water containing carbon dioxide. Limestone rocks dissolve very rapidly in this way. When water con-

taining carbon dioxide comes into contact with limestone, or any rock which contains lime, the lime is dissolved and carried away by the water, leaving behind only the impure part of the rock, or the part that will not dissolve, to form soil.

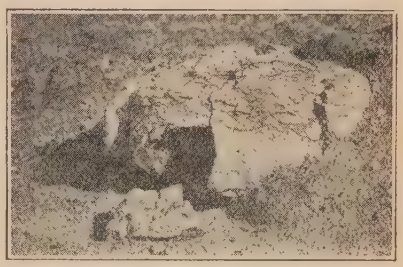
The Action of Air. Air, as well as water, is active in forming soil particles from rock. The wind, which is air in motion, beats against the surface of the rock, and gradually loosens the small particles and carries them away. When the wind works alone this process is very slow, but when the wind carries with it some sand particles and is moving very rapidly the cutting or grinding effect on any exposed rock is very noticeable. This grinding power of the wind carrying sand is so great that, along the seacoast, window glass is often made opaque during a single storm.

You have often noticed that iron, when left in a damp place, rusts; and that if you rub your hand over the iron it will be covered with a brown iron stain. Iron rusts because it has been exposed to the air and moisture. If a piece of iron is left so exposed long enough, it will rust entirely away. Just as iron rusts and becomes powdery when exposed to air and moisture, so portions of rock rust and become very fine. Some rocks which contain large quantities of iron may be entirely broken down into soil in this way.

The Action of Ice. At one time the north part of North America was covered with a great sheet of ice. This ice sheet moved southward slowly, passing over hills, valleys, and streams. In the bottom of this mass of ice were embedded rocks and boulders of all sizes, which acted as teeth to tear up the surface of the earth and grind away the rocks. This process of tearing down hills and filling

up valleys continued until the ice sheet moved so far south that the ice finally melted, and the material which it carried was deposited as soil. Soils formed in this way are known as glacial, or drift, soils.

The Action of Heat and Cold. Practically all rocks contain some water, either in their make-up or in the cracks and crevices. When the water in the cracks and crevices of the rock freezes it exerts a tremendous pressure on the rock fragments and tends to force them apart. In this way fragments are torn from the rock surface wherever any freezing takes place. Sudden changes in temperature also exert a strong pressure which tends to break rocks apart. Rocks are made up of different kinds of particles, called minerals. The different minerals do not expand and contract at the same rate on heating and cooling. Thus, when rocks become warm during the day, their different minerals expand at different rates, breaking the cementing material that holds the minerals together. In time, a rock at the surface of the soil may crumble down from this action.



A rock that is being broken up to form soil, by the action of water, heat, and cold.

The Action of Plants and Animals. Plants and animals work in various ways in forming soil from rock. The roots of plants, large and small, enter the small crevices in the rock, and force the rock apart, making the openings larger. Small plants, such as mosses, attach themselves to the surfaces of rocks, where they grow and

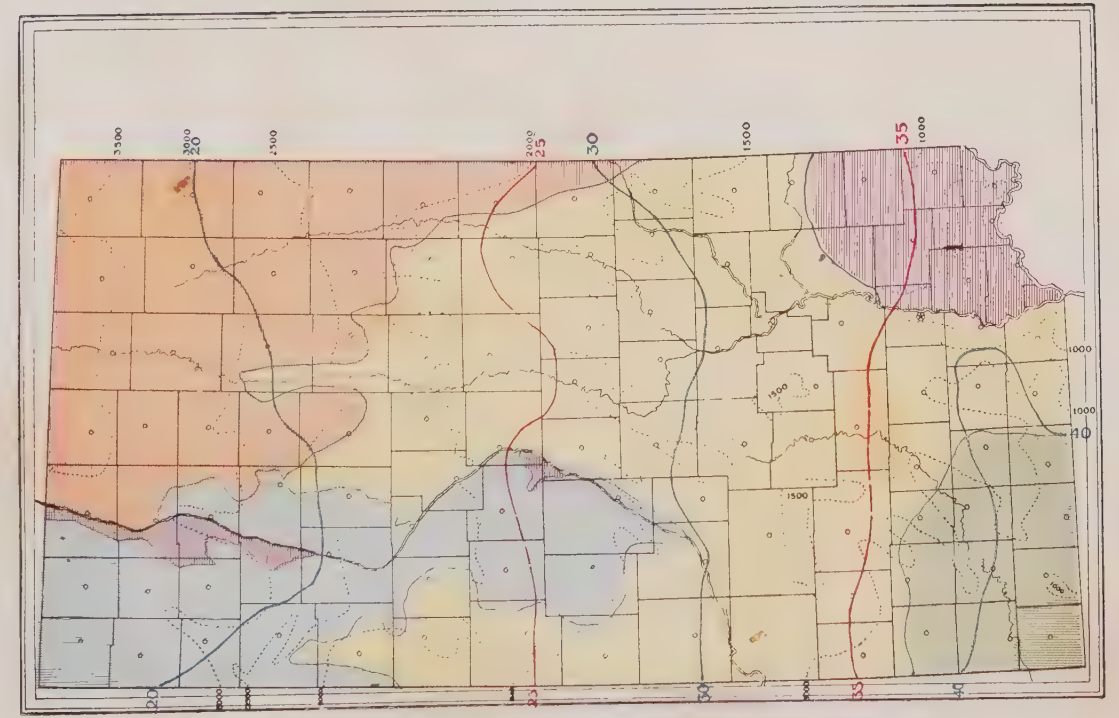
decay. These plants give off weak acids that dissolve the rock and loosen the rock particles. In this way little particles of mineral matter are added to the organic matter which is formed when the plants decay. Thus a soil is formed. This process is gradually continued until there is sufficient soil to maintain other plant life.

Burrowing animals, such as gophers, and worms, such as earthworms, also help to form the soil. They grind up and make finer the particles which have been formed by other means. They also make it possible, by their burrowing, for air and water to enter the soil and thereby to come into contact with the rocks below the surface.

Soils Formed from Plants. While most soils are formed principally from mineral matter, or rock material, there are in many places large areas of soils which have

A soil that remained where it was formed. Observe the ledge of rock below the soil. It was from similar rock that the soil above was formed.

been formed almost entirely from the decay of vegetation. Such soils are usually formed around shallow lakes, where there is a rank growth of vegetation which decays slowly



A SOIL MAP OF KANSAS

on account of the water, and which therefore gradually fills the lake, working inward from all sides. Soils formed from plant life or organic matter in this way are known as cumulose soils.

The Transportation of Soils. After the soil has been formed from rock and decaying organic matter, it may remain where it was formed, or it may be carried to some other location. Large bodies of the upland soils of central, eastern, and southeastern Kansas were formed in the places where they now exist. The soils in other parts of the state have been moved from the place of formation by water, wind, or ice.

Soils Formed by Water. The soils that occur along rivers and creeks and are commonly known as bottomland soils have been carried to their present location from the highlands adjacent to the streams. In time of flood a stream carries large amounts of soil material of various sizes. These particles of soil are deposited along the valley of the stream. The larger, heavier particles will be deposited first, near the stream, while the finer particles will settle out and be deposited where the water is running slowly, farther from the channel of the stream.

Soils that are transported in this way and redeposited are usually very fertile and form the most productive soils of the country. They are called alluvial soils.

Soils Formed by Wind. Soils that have been carried and deposited by wind are called loessial soils. Loessial soils are common in western and northwestern Kansas. The hard winds blowing from the west carried dust particles from the Rocky Mountains into western Kansas. As the winds slackened in velocity, the dust particles settled and formed the soil. The soils in western Kansas that have been formed in this way vary from a few inches to

many feet in depth. They usually contain large quantities of plant food, and are, therefore, very productive when supplied with sufficient moisture.

Soils Formed by Ice. Soils formed by ice are known as glacial soils. Such soils are found in the northeastern part of Kansas. The soils of that part of the state were brought from regions farther north by an immense glacier that covered northeastern Kansas as far south as the Kansas river and as far west as the Big Blue river. When this big glacier melted, the soil that it had carried from the north was deposited over this part of the state.

Glacial soils vary in depth as much as those that have been transported by wind. Where they are deep they

A glacial soil. The large rocks are boulders, commonly found in soils formed by glaciers.

are fertile. They comprise some of the best soils of the state. Large stones, called boulders, are usually found in glacial soils.

TYPES OF SOILS

The Soil Mass. The soil mass, as it occurs in the field, is made up of granules, or tiny lumps. These granules consist of large numbers of small soil particles of different sizes held together by moisture or some weak cementing material. Soil particles vary in size from those too small

to be seen by the naked eye to those that are commonly called stones or gravel. The soil particles are grouped, according to size, into classes named as follows:

1. Stones—particles of soil so large that they interfere with tillage operations.
2. Gravel—particles smaller than stones, but larger than $^1/_{25}$ of an inch in diameter.
3. Coarse sand—particles from $^1/_{25}$ to $^1/_{50}$ of an inch in diameter.
4. Medium sand—particles from $^1/_{50}$ to $^1/_{100}$ of an inch in diameter.
5. Fine sand—particles from $^1/_{100}$ to $^1/_{200}$ of an inch in diameter.
6. Very fine sand—particles from $^1/_{200}$ to $^1/_{500}$ of an inch in diameter.
7. Silt—particles from $^1/_{500}$ to $^1/_{5000}$ of an inch in diameter.
8. Clay—particles from $^1/_{5000}$ to $^1/_{250,000}$ of an inch in diameter.

These different-sized particles of soil are spoken of as soil constituents. While all soils contain most of the constituents, very few soils contain these constituents in the same amounts. Some of the most fertile soils do not contain stones or gravel, yet all fertile soils contain sand, silt, and clay. One soil may have the sand particles predominating, another the silt particles, and a third the clay particles. Thus different types of farm soils are formed as the amounts of these different soil constituents vary.

Sandy Soils. Sandy soils are made up chiefly of the soil constituents of the sand size. If coarse sand predominates, the soil is called a coarse sandy loam. If the fine sand constituents predominate, the soil is called a fine sandy soil. The coarse sandy soils are usually poor in plant food, and dry out very quickly. As a rule, the finer the sand that composes the soil the more valuable

the soil. Sandy soils are often very valuable for producing truck crops, like radishes, lettuce, and sweet potatoes. Sandy soils occur in Kansas along the Arkansas and Kansas rivers and on the uplands of the south central part of the state.

Clay Soils. Soils that contain more than thirty-five per cent of clay and more than sixty per cent of silt and clay are called clay soils. If the amount of silt and clay exceeds eighty or ninety per cent the soil is worthless for farming, because it is too stiff and heavy, and difficult to plow and work. The clay soils are usually very rich in plant food. When wet, they are sticky. When dry, they are hard, crack badly, and are lumpy. They are difficult to till. They must not be worked when too wet, else they will bake badly; and they can not be worked when too dry because they are so hard. These undesirable qualities of clay soils are due to the small amount of sand found in them. Sometimes manure or other forms of organic matter worked into these soils will take the place of sand and make them more mellow. The very heavy clay soils grow grass well and should be used for hay as much of the time as possible. The

A clay soil badly crusted. Soils of this type are very difficult to cultivate.

other crops that do best upon clay soils are wheat, oats, and barley, and some of the fruit trees, such as apple, pear, and plum trees. Alfalfa also does well upon clay soil wherever the plant can be started.

Loam Soils. A loam soil is made up of about one-half sand of the various grades, with the other half silt and clay. In physical nature it is half way between the sandy soil and the clay soil, and combines the best characters of both. It is easy to cultivate, does not bake or become cloddy if properly worked, and is usually rich in plant food.

There are different types of loam soils. Sandy loam contains more sand than loam, and more silt and clay than the sandy soil. Sandy loam is very common in the river bottoms of eastern Kansas. It is excellent for alfalfa and is well adapted to corn. Silt loam soil contains more silt and less sand and clay than the true loam. Silt loam is a very common type of soil on the uplands in all parts of Kansas. Loam and silt loam are the most desirable corn soils. Silt loam is also well adapted to the production of alfalfa, wheat, oats, and barley. Clay loam is intermediate between clay and loam soil. It contains more clay and less sand than does loam. Like clay soil, it is worked with difficulty, and must be handled carefully. It is fair corn soil, and is well adapted to wheat, hay and grass. Gravelly loam is a loam soil containing a large amount of gravel. This soil is not common in Kansas, occurring only in small areas. Stony loam is a loam soil containing a large number of stones. This type occurs in Kansas merely in small areas, and is useful only as pasture land.

THE SOILS OF KANSAS.

The soil map on the adjacent page shows the general location and extent of the six great divisions of Kansas

soils. No sharp lines of demarcation can be drawn between any two of these soils.

In the extreme northeastern corner of the state, extending south to the Kansas river and west almost to the Blue river, is a body of soil known as glacial, because it was carried there and left by the glacier which came down from the north.

The large body of soil covering the northwestern portion of the state is known as loessial, or wind formed, soil. The soils of that area were carried from other regions by the wind and deposited there.

The area of soils in the southwestern part of the state is residual, being formed from the unconsolidated material which was at one time carried there by water from the country farther west.

Just south of the Arkansas river in the western part of the state is what is known as the "dune sand" area. The sands of this area were at one time moved from place to place by the wind.

The soils in the southeastern part of the state are residual in origin, and have been formed largely from the weathering of sandstone and shale.

The broad body of soils found chiefly in the central part of the state, but extending from the northern to the southern edge, and from the central to the eastern edge of the state, is residual in origin. It has been formed largely from the weathering of limestone, sandstone, and shale.

QUESTIONS

1. Of what is the soil composed? How may its composition vary?
2. How does the soil differ from the subsoil? What constitutes a good subsoil?
3. Why is the subsoil in eastern Kansas less productive than the soil?

4. Name all the agencies which have a part in soil formation. Tell what each does, and how it does its work.

5. How are cumulose soils formed? How have glacial soils been formed?

6. In what ways may soil be transported?

7. Of what is the soil mass composed?

8. What are the disadvantages of a sandy soil? What are the disadvantages of a clay soil? Contrast the disadvantages of clay soils with those of sandy soils.

9. Why is a loam soil desirable? To what crops is it adapted?

CHAPTER XVI

SOIL WATER

There can be no plant growth without water. One of the most important uses of the soil is to act as a storehouse for water until it is needed by the plants. It has been estimated that a thousand pounds of green corn contains about eight hundred pounds of water; that is, that four-fifths of the corn plant is water. It can, therefore, safely be said that the most important food that the plant takes from the soil is water. The soil water is important, not only because it is the chief plant food, but because it acts as a carrier of all other plant foods that come from the soil. The soil itself is not the original source of this water; the water comes from the atmosphere as rain. Water which comes to the soil as rain exists in the soil chiefly in two forms, free water and film water.

Free Water. Free water is that which flows under the influence of gravity. It is also called ground water, bottom water, or standing water. Well-drained soils contain free water only for a short time after heavy rains; it either flows off the surface of the ground or sinks downward into the lower soil. The downward movement of the water through the soil is called percolation.

Free water is not directly useful to the roots of plants, except those which naturally inhabit swamps, like rice, willow trees, and pond lilies. If free water stands in the soil very long, most farm crops will be drowned, for the roots of such plants must have air, and this water excludes

the soil air. Free water is indirectly useful in supplying film water.

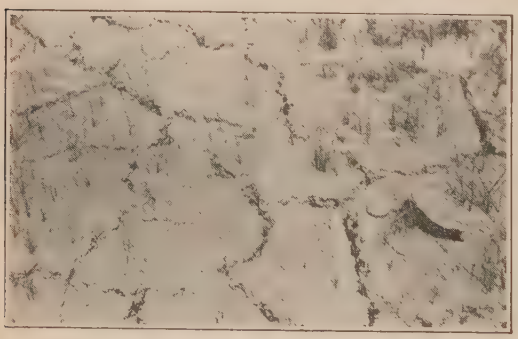
Soils that are composed of large particles, like sand, have large openings between the soil grains. Through these soils water percolates very rapidly, and not enough film water is supplied. Soils composed of small particles, like clay, have very small openings between the soil particles. Through soils of this kind water percolates very slowly—so slowly that plants are sometimes drowned. Soils with medium-sized particles, like loam, permit water to percolate fast enough to prevent the plant from drowning, and yet slowly enough to supply an abundance of film water.

If plant material, like manure, is added to a sandy soil, the large openings between the soil particles will be partly closed, water will percolate less rapidly, and the sandy soil will become more like loam. If the same kind of material is added to a clay soil, the small particles will be forced farther apart, the openings will be made larger, and the clay soil will be improved. Water that percolates into the soil may be brought back for the use of the plant. It is therefore desirable to have fine-grained soils, like clays and loams, loose, so that they will absorb as much of the rainfall as possible.

Film Water. Water is also present in the soil as film water. This water is called film water because it surrounds each soil particle with a thin film. When all the free water has percolated through the soil after a rain, each soil particle is surrounded by film water. It is this water surrounding the soil particles that the plants use in their growth. The amount of film water that can cling to one soil particle is very small, but the amount of water that can cling to all the soil particles is very large. A good farm soil may sometimes hold more than one-half its

weight of film water. The amount of this water the soil can hold depends upon the size of the soil particles. Those soils having the smallest particles, such as clay, hold the most film water.

Film water is called also capillary water. It rises in the soil in the same way that oil rises in a lamp wick. If the ends of small glass tubes are immersed in water, water will rise on the inside of the tubes. The smaller the bore of the tubes the higher the water will rise. Capillary water rises in the same way in the soil. The smaller the soil particles the smaller will be the soil capillary tubes, and consequently the higher the water will be raised in the soil. Therefore, fine-grained soil will raise water to a greater height than will coarse-grained soil. Free water that percolates into the soil is brought back for the use of plants by the action of the force called capillarity. Therefore, the greater the quantity of water that is stored in the subsoil, the greater is the amount that may be brought by capillarity into the soil for the use of growing plants.



Soils when cracked lose moisture rapidly. A soil should be cultivated to prevent this loss of moisture.

Water moves by capillarity from a wetter to a drier soil. If water is evaporating from the surface of a soil, additional water will be brought from the lower soil to replace it. In this way it is possible for soils to dry out to a great depth. If one is to save

the water for the use of crops, one must prevent evaporation from the surface soils. Evaporation can be greatly checked by covering the soil with some material through which water passes slowly.

Soil Mulches. A material placed upon the soil to prevent evaporation is called a mulch. There are two kinds of mulches, foreign mulches, and natural, or soil, mulches.

A good soil mulch on a corn field. Very little water is lost by evaporation from such a field.

Stones, sand, sawdust, and straw scattered over the surface of the soil, form good mulches and greatly check evaporation. These mulches can be used only in a limited way. They are foreign mulches.

A soil mulch consists of a layer of soil which has been loosened by cultivation, and which, because of its loose, open structure, dries out quickly and prevents evaporation.

When a soil is stirred after a rain, evaporation will first be increased, but as the loose soil becomes dry it acts as a mulch to prevent further evaporation. It is not best to have the mulch broken up so fine that it forms a dust, for moisture will rise through this more rapidly than through a mulch composed of small lumps, or granules. A dust mulch is also much more likely to blow than a mulch composed of small lumps. If best results are to be obtained it is necessary to cultivate as soon as possible after a heavy, packing rain, in order that the crust, which allows moisture to escape, may be broken up. The depth to which the soil should be cultivated for this purpose depends upon whether the soil is composed of fine or of coarse particles. Cultivating three inches, however, usually produces an effective mulch.

A listed field. On a field of this character, rain soaks into the soil rapidly.

Increasing the Water-holding Capacity. Tillage may be beneficial in increasing the water-holding capacity of a soil, as well as in preventing loss by evaporation. Plowing fine-grained soils, like clay or loam, so as to leave the surface soil rough and uneven, helps to prevent surface run-off when heavy rains fall. If the soil is plowed early

and deep the opportunities for it to absorb and hold moisture are increased, because, the larger the volume of soil loosened and made open, the more water it will be capable of holding.

Dry Farming. Over a large area of western Kansas the rainfall is not sufficient for the production of a good crop each year under the usual methods of cultivation. Where conditions of this kind prevail, dry farming is practiced. Dry farming is not an attempt to grow crops without water, but consists in conserving water so that crops may be grown with the minimum amount of rainfall. By this

Injury from blowing due to improper handling of the soil.

system of farming, as much as possible of the water that falls as rain is stored in the soil for the use of plants during their growth. To store water thus, it is necessary to have a deep subsoil that is open enough to allow the entrance of water, and at the same time composed of fine grains and compact enough to hold a large amount of moisture and have considerable capillary power. The sur-

face soil should be loose and open, and the ground should be cultivated to prevent the growth of weeds.

Where blowing occurs the ground must be kept rough, and must be cultivated only when moist, and then no more than is necessary to kill the weeds. Perhaps the best system is to list the land in the fall and allow it to remain in a rough condition during the winter months, and in the spring to cultivate only with implements that leave the ground in a rough condition. The spring-tooth harrow, the shovel cultivator, and the alfalfa renovator are good implements for this purpose. If the soil is cultivated with the smoothing harrow and so disked as to leave the surface smooth, blowing will result.

When the rainfall is very light, ground is sometimes summer-fallowed for one year out of three or four, for the purpose of storing moisture in the soil. Summer-fallowing consists in cultivating a field thoroughly an entire season without a crop and without letting the weeds grow. When this plan is followed, the rainfall of one year is stored in the soil and held until the next year, when it aids the rainfall of that year in growing a crop. If the moisture is properly cared for, it is necessary to cultivate the field often enough during the fallow year — the year in which no crop is grown — to keep weeds from making much growth, for weeds use large amounts of moisture and soon deplete the soil of its supply. The cultivation of the soil during the fallow season involves some extra expense, but there is no expense for seed and harvest in the fallow year, and there is often a larger net profit in growing two good crops every three years than in growing a small crop every year.

SOIL EROSION

Soil erosion is the washing away of the surface soil. In northeastern Kansas, where the rainfall is heavy and the

soil loamy and rolling, much difficulty is experienced in keeping the surface soil in cultivated fields from washing away. The surface soil contains the most plant food and is therefore the richest part of the soil. When washed away, it leaves behind only the poorer subsoil. Not only does erosion carry away plant food, but it also causes deep ravines in the field, which make cultivation very difficult.

When the country was all in grass, the amount of erosion

Farm land that is rapidly being destroyed by washing.

that took place was very small in comparison with that which has taken place since the ground was plowed. As the land was broken up by the plow, the surface covering of leaves, grass, and twigs, which held large amounts of moisture as it fell in the form of rain, and which gave it up slowly to the soil, was destroyed. The roots of grasses, weeds, and trees, so numerous in the soil, aided greatly in holding the soil particles together. The presence of large

Contour plowing or listing is often very helpful in preventing washing. Listed furrows also catch and hold the snow in winter.

amounts of organic matter in the soil tends to prevent erosion, because such matter holds large amounts of water, thus lessening the surface run-off, and also it binds together the soil particles. When the farmer plants most of his cultivated land to corn each year, the organic matter in the soil soon decays and the soil washes much more easily.

The Prevention of Erosion. Since erosion is caused by the water's carrying off the surface of the ground, anything that will lessen the surface run-off will lessen erosion. Adding organic matter to the soil and deep plowing are both beneficial on ground that must be cultivated, but the best method of preventing erosion is to keep the more rolling fields seeded to alfalfa or some grass.

If it is desirable to cultivate a field which has considerable slope and a tendency to wash, the land should be plowed or listed with the contour of the field, and the crop planted in the same way. This system of plowing is known as contour plowing. The furrows, in this case, form a series of small terraces in the field, and thus aid greatly in the prevention of erosion.

QUESTIONS

1. Why are the amount and the kind of water in the soil of so much importance to the farmer?
2. In what forms does water exist in the soil?
3. Is free water useful in the soil? How?
4. How may the water-holding capacity of a sandy soil be increased?
5. How do coarse-grained and fine-grained soils differ in water-holding capacity? Of what importance is this to the farmer?
6. How may moisture be lost from the soil? When may this loss take place most rapidly?
7. What is a soil mulch? What is its value?

8. What effect has tillage on water-holding capacity? When may tillage be used to greatest advantage in controlling soil moisture?

9. In summer-fallowing, why should the land be left in a rough condition over winter?

10. How may soil erosion be prevented?

CHAPTER XVII

SOIL IMPROVEMENT

The soil must be fertile and rich if the farmer is also to be rich and happy. On a rich soil a farmer can grow big crops of corn, wheat, and alfalfa. Where large crops are grown there is plenty of feed for live stock of all kinds. On a poor soil it is impossible to grow good crops, and without good crops the farmer can not grow the best live stock. It is necessary, therefore, if the farmer is to be prosperous, for him always to keep his soil rich and productive. A soil will not remain rich if care is not taken to keep up its fertility. We have seen how organic matter is lost from the soil; this must be supplied, a little each year, or the soil will become poorer. A fertile soil al- contains plant food.

There are a number of kinds of food necessary to the growth of the plant. Three of these plant foods, nitrogen, phosphorus, and potassium, sometimes become used up by too many years' cropping of the same land. Unless the deficiency is supplied, the soil becomes poor and unproductive. There are three ways of adding plant food: (1) growing a leguminous crop that will secure nitrogen from the air; (2) applying commercial fertilizer; and (3) applying barnyard manure to the soil.

Leguminous Crops. Leguminous crops, as has been pointed out, have the power to secure nitrogen from the air. Three-fourths of the air is made up of nitrogen, so that there is plenty for these crops to use. The most common

leguminous plants are alfalfa, clover, cowpeas, soy beans, beans, and peas. Leguminous plants are able to use the nitrogen of the air because they have living with them, in nodules on their roots, friendly bacteria.

The bacteria first take the nitrogen from the air and then give it to the plant. These bacteria in return must have carbon for their growth. They are not green, neither do they grow in the sunshine; therefore, they can not take the carbon from the air as does a plant. But the legume has green leaves and can use the carbon of the air, and it supplies the bacteria with its carbon. Thus these two friends, the legume and the bacteria, live together, each doing a work that the other can not do.

Most soils contain these useful bacteria. Some soils may not contain them, in which event the bacteria must be introduced. The best way of inoculating with bacteria is to gather soil from a field where the legume to be sown has been successfully grown, and to spread the soil at the rate of two or three bushels upon each acre to be inoculated.

How Legumes Help Other Crops. These friendly bacteria live only upon the roots of leguminous plants. No other plants have nodules on their roots. Therefore, leguminous plants are the only plants that can use the nitrogen of the air. Corn, wheat, oats, and kafir must obtain all their nitrogen from the soil. When alfalfa, cowpeas, clover, or any other legume has been grown upon a field, there is left in the soil some of the nitrogen that the plant took from the air. This is especially the case if the crop is pastured or is plowed under for green manure. If corn or wheat is then planted on the field where the legume has been grown, the crop is greatly benefited by the nitrogen left in the soil by the leguminous plant. In this way a farmer may place in the soil nitrogen from the

air for the use of crops like corn or wheat, which are dependent upon the soil for their nitrogen.

Commercial Fertilizers. A commercial fertilizer is a material sold for the purpose of supplying plant food to the soil. When a commercial fertilizer supplies all three of the important kinds of plant food, nitrogen, phosphorus, and potassium, it is called a complete fertilizer. Large amounts of commercial fertilizers are used by farmers in Europe, especially in Germany, France and England. In the United States, commercial fertilizers are used in the southern and the eastern states, where the land has been cropped for a great many years, but in the western states, like Kansas, where the ground has not been cropped so long, fertilizers are not extensively used. As time goes on and as more and more plant food is removed from the soil, it will become necessary to use fertilizers in order to produce profitable crops. While commercial fertilizers supply plant food to the soil, they do not furnish much organic matter. We have seen that organic matter, as well as plant food, must be supplied if the soil is to remain fertile. For this reason, a farmer can not expect to maintain the fertility of his soil by using commercial fertilizers alone. They should be used, for best results, on soil which is occasionally dressed with barnyard manure or on which a crop is plowed under occasionally to supply organic matter.

Barnyard Manure. Barnyard manure is the most important of all kinds of plant food, and also adds organic matter to the soil. It is also the cheapest source of plant food. The farmer who feeds all the crops grown on his farm to live stock and carefully saves and returns the manure to his fields, will not find it necessary to buy much

commercial fertilizer. The average farmer who is feeding live stock on his farm does not carefully save and use the manure.

Barnyard manure that has accumulated for years. It has lost much of its plant food. It should have been spread on the fields as fast as it was made.

It has been estimated that there is produced annually in the United States manure containing plant food valued at more than two billion dollars, and that one-third, or more than seven hundred million dollars' worth, of this plant food is lost by careless handling. Loss of plant food from manure may occur in several ways.

The Loss of Manure Value. Manure is made up of both solid and liquid matter. The latter is the more valuable because it contains more plant food, and also because the plant food which it contains is soluble in water and readily available for the use of plants. If care is not used in handling the manure, this valuable liquid material will flow away and be lost. This loss may be prevented by using sufficient bedding to absorb all the liquid portion of the manure. Manure that is left in the feed lot over summer, or that is piled in the open and left exposed to the weather, loses large amounts of plant food. Rain carries away in solution enormous quantities. This loss may be largely overcome by feeding the cattle on the cultivated land in the winter when the ground is dry, by cleaning out the feed yards early in the spring, and by piling manure

under cover when it must be stored, and hauling it to the field as soon as possible.

Barnyard manure that has been exposed to the weather for a period of six months has lost one-half of its plant food, and only the more slowly available plant food remains.

The Application of Barnyard Manure. If the best results are to be obtained from barnyard manure, it should be hauled to the field as frequently as possible and spread over the surface of the soil evenly. It should not be placed in small piles and then scattered later, because it will lose a part of its value while in the piles, and the spots where the heaps were placed will receive an excessive amount of plant food.

Manure that is applied as a surface dressing to wheat, alfalfa, or pasture lands at the rate of from five to ten tons

The yield from one-tenth of an acre of alfalfa, first cutting. 1. Unfertilized. 2. Fertilized with five tons of manure to the acre annually. 3. Fertilized with two and one-half tons of manure annually. 4. Fertilized with two and one-half tons of manure and three hundred and eighty pounds of rock phosphate annually. 5. Unfertilized.

an acre will cause, under most conditions, a good increase in yield. Manure should not be plowed under, especially in western Kansas. When a heavy dressing of manure is

plowed under, the soil is left so loose and open that crops suffer severely from drouth.

HUMUS

From the definition of the word "soil" we learned that soil is composed of rock material and plant material. We have seen how the rocks of the earth's crust have been broken down and transported from one place to another to aid in the formation of the soil. The plant material in the soil is usually spoken of as the organic matter. The organic matter of the soil is slowly decaying. If it decays on the surface of the soil, it gradually disappears, leaving nothing but ashes, as though the organic matter had been burned. If it decays partly buried in the soil, as when the organic matter is plowed under, it forms, in place of ashes, a black material called humus. Humus is, therefore, organic matter that has partly decayed in the absence of air. It is in the form of humus that most of the organic matter of the soil is found. Humus is necessary for the growth of good crops. While plants may be grown under unnatural conditions in a soil that contains no humus, they can not be grown in the field in a soil of that kind, as

Nature's way of adding organic matter to the soil: weeds growing on an uncultivated field.

they can not obtain enough food. Nitrogen, one of the most necessary foods of plants, is found in the soil chiefly in organic matter and humus. In decaying, humus also makes available to plants many of the other plant foods in the soil. Humus increases the water-holding power of the soil, because it acts like a sponge in absorbing water. It is for this reason very valuable in sandy soil. Soils that do not contain humus in fairly large amounts are worked with difficulty, are hard to plow and cultivate, and after rains bake and crust badly.

How Humus is Lost. The organic matter and humus of the soil come from the vegetation that grows upon the earth. In nature, before man started to till the soil, there was always an abundance of humus, for all plants fell down and decayed where they had grown. When man started to till the soil, plants were no longer allowed to fall down and decay where they grew, but were removed from the fields. Man required the crops for food for himself and his live stock. He not only removed the crops, but plowed and cultivated the soil. In the plowing and cultivation of the soil, air was allowed to enter freely, and the decay of organic matter was hastened. Thus the humus of the soil that nature constantly planned to maintain has been reduced by man, first, in removing from the fields the crops, which, if left to decay, would have formed organic matter in the soil; secondly, in plowing and cultivating, and thus hastening the decay of the humus previously stored in the soil.

How Humus May be Supplied. As more and more of the organic matter is destroyed by such methods of farming as the growing of corn continuously and the removal of all fodder and straw from the farm, with the addition of no plant material, the soils become less and less productive. They become hard, are difficult to cultivate,

bake when dry, wash badly, take in water slowly, and dry out quickly. Thus soils that were once productive and fertile become in time so poor that they no longer produce paying crops.

Must man, in order to keep up the humus supply, go back to nature's plan and take nothing from the soil? He will do well to study nature's plan, and imitate it as far as possible. All organic matter produced upon the farm should be returned to the soil. Cornstalks supply organic matter. They should not be burned; for in burning the organic matter is destroyed. They should be worked into the soil, where they will decay and form humus. Straw supplies organic matter, and therefore should not be burned.

Old straw stacks rotting in the field. Straw supplies organic matter and should not be burned or allowed to rot in the stack, but should be spread and worked into the soil to form humus.

All manure produced by live stock supplies organic matter, and should be saved, spread upon the field, and worked into the soil. If not enough material can be returned to the soil in this way to keep up the supply of organic matter, then crops should be grown and plowed under for the purpose of furnishing this material to the soil. Crops grown and plowed under for the purpose of furnishing organic matter to the soil are known as green manuring crops.

Green Manuring. The best green manuring crops for Kansas are cowpeas, soy beans, sweet clover, and red clover. These are the best green manuring crops because

they add to the soil large amounts of nitrogen, as well as organic matter. Next in importance are rye, sorghums, and similar crops. These crops add large amounts of organic matter to the soil, but do not add nitrogen, and therefore are not so valuable as the others.

Plowing cowpeas under—an excellent means of adding organic matter to the soil.

Lime and Liming. There are soils that fail to produce certain crops, not because the soil does not contain sufficient plant food, but because the soil is not in the proper condition to furnish a favorable home for the plant. Any material that is used to improve this condition is called a soil amendment. The chief soil amendment is lime. Soils that are deficient in lime do not furnish a suitable home for the bacteria that live on the roots of leguminous plants and aid in the fixation of nitrogen from the air. It is therefore necessary to lime such soils before leguminous crops like alfalfa, clover, and sweet clover can be grown.

In the eastern and southeastern parts of Kansas there

are large areas of soil that are deficient in lime and will not grow alfalfa or clover satisfactorily. Such soils soils should be limed. Lime may be used in one of two ways: it may be applied to the soil as finely ground limestone; or it may be applied as burned lime.

If lime is applied as finely ground limestone, it should be used as a surface dressing and should be harrowed in. Because of its slow action, it should be applied a year before results are expected from it. If, however, burned lime is to be used, it should be allowed to slake before being applied, and should then be spread as a surface dressing and should be harrowed in immediately. It is not advisable to apply lime and manure together, because the lime will set free from the manure nitrogen which will escape into the air.

QUESTIONS

1. In what three ways may plant food be added to the soil?
2. How do leguminous crops improve the soil?
3. Is it advisable to apply nitrogen as a commercial fertilizer? Give reasons for your answer.
4. Why is barnyard manure such a valuable plant food? When and how should it be applied?
5. How should barnyard manure be cared for before it is applied?
6. Why is humus so valuable in the soil? Give all the reasons you can. How may we tell when a soil lacks humus?
7. How may humus be lost from the soil? How may it be added to the soil?
8. To what soils should finely ground limestone be applied? Why?

CHAPTER XVIII

DRAINAGE

Land drainage is the removal of excess water from the soil. In order that crops may be profitably grown, it is necessary that the soil shall not hold an excess of water. Too much water excludes air and hinders the activity of soil bacteria, and in other ways makes the soil unfit for plant growth. Soils which are open and porous permit this excess water to flow away by gravity, and are drained naturally. Fine-grained soils with little vegetable matter and humus, or soils which have heavy, compact subsoils, do not permit this excess water to escape readily, and are therefore not naturally adapted to agriculture. In order to make these soils fit for plant growth, artificial drainage and proper tillage are necessary. Fortunately the excess water which hinders plant growth may be removed by the action of gravity without removing the capillary water necessary to plant growth.

Lands Requiring Drainage. Lands which accumulate an excess of water and make drainage necessary are frequently found. Many fields have a part or all of their area made up of such soils. The most common conditions are: ponds and sloughs holding water for a great length of time; low spots and wet draws in cultivated fields which dry slowly after heavy rains; undulating fields having apparently good surface drainage, but having spots which are wet because of the retentive or uneven subsoils which cause the water to seep out near the bottom

of a slope; fields with porous or loamy surface soils, but with heavy, compact subsoils which prevent natural drainage; low-lying swamp or marsh lands, or other areas without sufficient slope to remove the excess rainfall rapidly enough; stream valleys which are periodically overflowed because of the limited capacities of river and creek channels, and which must be protected by some method of stream improvement.

Many soils, on account of their steepness, erode or wash very badly. In such cases the problem is not how to permit the water to run away more quickly, but how to handle the water to prevent soil erosion. Soil erosion can not be prevented by artificial drainage alone. Proper tillage and rotation of crops are necessary for successful protection.

Artificial land drainage is accomplished by two distinct methods: surface drainage, and underdrainage.

Surface Drainage. A large proportion of the rain which falls upon the earth's surface runs away over the surface of the ground. This water gathers in pools and small surface channels, and is finally collected into the creeks and rivers, which carry the surplus away to larger bodies of water. In cultivated fields, adequate surface ditches are necessary to carry away the excessive storm water. Nature provides at all times a means for removing this water, and if it is not permitted to escape by gravity through the surface channels, either it will gradually evaporate or it will percolate downward through the drainage pores in the soil. Evaporation is slow, and in most cases the character of the subsoil will not permit rapid or free percolation downward; therefore, the most important step in land drainage is to secure proper and adequate systems of ditches for surface drainage. It should be remembered, however, that surface drainage is valuable only so far as it

is capable of removing water which would otherwise stand upon the surface of the ground.

Drainage Ditches. Surface ditches are necessary in any large system of drainage, as a means of escape for the surface run-off and as an outlet for underdrains. It is very important that these surface drains be located to give proper outlet for all the wet land, and at the same time be placed in such a manner as to prevent, as far as practicable, irregular-shaped fields. Generally speaking, surface drains are located to follow the general course of natural drainage.

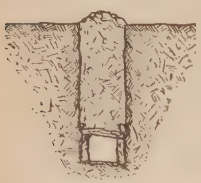
A type of mechanical excavator used in making open ditches.

Open Ditches. All ditches must have a certain amount of slope, or fall, in order to carry away the water. Frequently the amount of fall across a tract of land is not sufficient to provide adequate slope in the channel to permit the water to escape. In such cases, the lower end, or outlet, must be dug to a greater depth than the upper end. On the other hand, the slope of the land may be so great as to cause the water to run so rapidly that the soil is washed away. The channel should be so located as to prevent this, and if possible just enough fall should be secured to give sufficient velocity to carry away the silt and other debris that will naturally enter the channel.

The character of the soil is an important factor in locating the ditch.

Underdrainage. Underdrainage deals with the removal of excessive moisture from within the soil by means of covered drains. Although proper surface drainage is the first step in farm drainage, it frequently becomes necessary, even after surface drainage has been secured, to remove water from within the soil. To accomplish this purpose underdrainage is necessary. Some soils are of such a texture that they do not require artificial drainage, but few localities are so fortunate as to have soils that do not require more or less underdrainage.

Kinds of Underdrains. An underdrain consists of an underground conduit or covered channel for the proper removal of excessive ground water. The first type of underdrain consisted of bundles of sticks placed in trenches, the whole being covered with earth. Following this crude method, broken stone was placed in the trenches and the water was permitted to percolate through the open cavities. Later, flat stones were used to form underground channels. Tile drains were first introduced into the United States in the state of New York in 1838. Some of these drains are still in use.



Underdrain made with flat stone.

A modern tile drain.

Tile Drains. Clay and cement are now extensively used for the manufacture of underdrains. The clay tile is used more generally than any other type. Factories for the manufacture of this product are well distributed throughout the Mississippi valley. Cement tile, made of

a mixture of cement and sand, is now extensively used. When properly constructed, cement tile is entirely satisfactory for drainage purposes. It is necessary that this underground pipe be made of first-quality material, otherwise the pieces are liable to crumble and break. Clay and cement tile are manufactured in diameters varying from three inches to several feet. Tile drains less than twelve inches in diameter are usually constructed in lengths of twelve inches. For drains of greater diameter the pieces of pipe are longer.

Digging a drainage ditch.

It is very important that a good outlet be secured for tile drainage systems. In other words, there must be proper open ditches to permit the water from the tiles to escape readily. Tile drains are laid in trenches of varying depths, and always on a general line of descent, so that the water can have a free flow throughout the pipe line. The depth of trenches for receiving the tile varies with the character of the soil. Tile drains are usually placed at depths of not less than thirty inches, and in certain localities where the soil is deep, from three to four feet below the surface. In general, hardpan or very retentive soils require shallow drainage, while loamy bottom lands require deeper drainage.

Tile Drainage Systems. A tile drainage system consists of a main, submains, and laterals. The main tile line serves as an outlet for all other drains, and should ordinarily be located in the lowest part of the field and along the general course of natural drainage. Into the main

Draining a field. Notice depth and relation of ditches, and distribution of tile.

tile line the submains will empty, and these submains will in turn be the outlet for the lateral drains. The position of the submains depends largely upon the natural slope of the land. The laterals should be placed sufficiently close together to give complete and satisfactory drainage to the land. These intervals may vary from twenty-five to one hundred feet or more. Open and porous soils do not require frequent drainage. In such soils the tile are placed

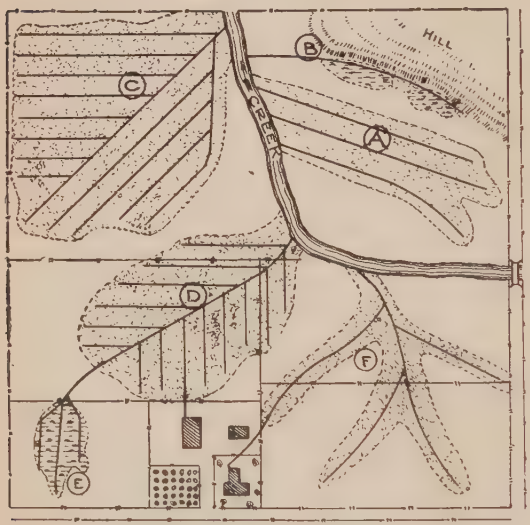
deep, and the lines fairly wide apart. In localities where the soil is very retentive, the tile lines are necessarily placed at less depth and at more frequent intervals. It is apparent that there is a relation between the depth and the spacing of tile lines, and that this relation is dependent directly upon the character of the soil to be drained.

Size of Tile. The proper size of the underdrain depends upon the area of land to be drained and the slope, or fall, in the tile line. Drains should be installed to relieve the land of the excessive water during times of heavy rainfall. It is evident that the main tile line must be large enough to carry the combined water of all the drains which enter into it. Lateral tile lines should not be less than three inches in diameter, and usually it is economical to make the diameter at least four inches. The length of these lateral tile lines depends upon the topography of the land, but the minimum size of tile should not be used for a length much exceeding one thousand feet. It is very important to have the tile drains large enough, otherwise they will fail when most needed; that is, during the wettest weather.

Placing the tile in trenches.

Drainage Systems. Different systems of tile drainage are adapted to different fields. Where only wet depressions exist in the land, tile drains are placed in the lowest part of the wet area, and tile lines are run out into the wet side draws as required. This method is known as the natural system of drainage.

Broad wet draws that are naturally depressed toward the center are drained by a main tile line through the center of the wet area and lateral lines run out from either side of the main line. This is known as the herringbone system.



Plan of typical drainage system for a 160-acre farm. *A*, Single-line system of drainage. *B*, Cut-off drain to intercept seep water from the hill. *C*, Gridiron system of drainage for flat land. *D*, Herringbone system of drainage. *E*, Drainage of a pond. *F*, Natural system of drainage; also note the drain to the farm buildings.

For large tracts of land where complete and thorough drainage is required, the system consists of long parallel lines of tile so arranged that they will cover every portion of the field thoroughly, yet have a common outlet. Such a system of drainage is known as the gridiron system.

Areas having a uniform slope with a good natural outlet are sometimes drained by single lines of tile laid through the field; each tile line in reality is a system of drainage. This is known as the single-line system.

Sloping hillsides are sometimes drained by tile lines placed at an angle with the greatest slope. This is known as the cross-the-slope system.

Undulating, or rolling, land that is subject to seepy or wet conditions at the base of the hill slopes is successfully drained by a tile line placed above the wet outcrop and deep enough to intercept the source of the seep water. Drains of this character are known as cut-off drains.

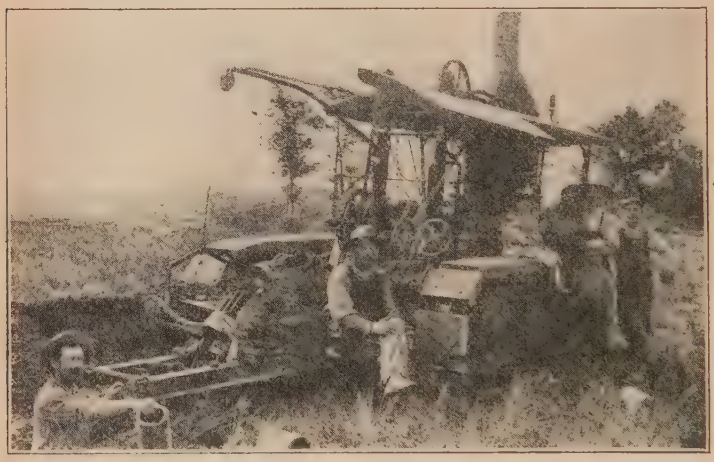
Construction Methods. Farm drainage systems are usually constructed by the use of hand tools. The implements usually needed are a tile spade, a shovel, a drain scoop, and a tile hook. Tile spades have blades ranging from sixteen to twenty inches in length. These are used to loosen and throw the dirt from the trenches. The shovel is used to remove the loose particles from the bottom of the trenches, and the drain scoop to shape the bottom to receive the tile. The tile hook is used to place the tile in position in the bottom of the trench.

In localities where a large amount of tile drainage is necessary, power ditching machines may be used. These machines are run by steam or gasoline engines. In one operation they cut the ditch and shape the bottom of the trench ready to receive the tile.

The Action of Tile Drainage. When a field is tile-drained the surplus water that falls percolates into the soil by passing through the drainage pores until it comes into contact with the underdrains. Here the action of gravity causes the water to enter the tile through the cracks at the joints. The quantity that enters through the sides of even the most porous tile is not worth considering. With the most careful laying there is always ample room for the water to pass through the joints, and it is found that the longer the tiles are laid, the better defined the drainage pores in the soil become; consequently, the better the drainage.

A drainage system that appears unsatisfactory when first installed may prove to be entirely adequate in the

course of time. Porous soils naturally respond most readily to underdrainage. The action of the tile drains in close, compact soils is hastened by deep plowing and subsoiling, and the drainage properties of the soil may be improved by methods of farming which introduce vegetable matter into the soil.



A mechanical excavator used in the construction of tile drainage systems.

The Benefits of Drainage. While the principal purpose of the tile drain is to make wet land productive, it performs additional functions in making the land sweeter by proper aëration, warmer by preventing excessive evaporation, more productive by increasing the depth of soil, and more resistant to drouth by making more moisture available for plant life. Underdrainage is a valuable agent in the development of farm lands, in that the waste areas on the farms are decreased and thereby the value of the entire farm is increased. If underdrainage is employed fields can be made more regular in shape, and therefore can be

cultivated more easily. The removal of stagnant water lessens the danger of disease, while the dry earth about the farm buildings makes the farm home more sanitary. Localities which are properly drained have about them an air of freshness that is not possible in wet, low-lying districts.

QUESTIONS

1. What is the purpose of land drainage?
2. Name six conditions of wet land which make drainage necessary.
3. Under what two general divisions may land drainage be classified?
4. What do you understand by surface drainage? What is the purpose of the surface ditch?
5. Give some general principles to be observed in the location of open ditches.
6. What do you understand by underdrainage? How is artificial underdrainage accomplished?
7. Of what materials are tile drains usually made?
8. Give some of the important principles to observe in the location and construction of tile drains.
9. Of what does a tile drainage system consist? Name and describe five different systems.
10. What tools are required to construct a tile drainage system by hand?
11. What is the minimum size of tile which should be used in a drainage system?
12. Describe the action of tile drains.
13. Give five benefits derived from tile drainage.

CHAPTER XIX

IRRIGATION

The application of water to the soil by artificial methods for the production of crops is known as irrigation. The practice of irrigation is more ancient than history; the earliest known writers refer to this method of agriculture and give rules for the handling of water. India has more than 40,000,000 acres of irrigated land; Egypt has 6,000,000 acres; the United States has between 15,000,000 and 20,000,000 acres. Practically every nation in the world irrigates to some extent. The first irrigation practiced in the United States was carried on by the Mormon settlers in the Salt Lake valley, Utah, in 1847. About twenty years later California and Colorado began to irrigate. To-day all the states in the semiarid and arid parts of the United States are practicing irrigation.

The Need of Irrigation. Wherever there is insufficient rainfall some method of irrigation is necessary for the full development of crops. The greatest need for irrigation is in regions of slight rainfall or in regions where rainfall does not come at the proper times during the growing season. Not only is irrigation valuable as a means of making dry and desert lands productive, but it is also a valuable agent in the semiarid and the humid districts in carrying crops through critical periods during the hot, dry summer months.

The Advantages of Irrigation. Irrigation provides the required amount of moisture for the growing vegetation at

the time when it is most necessary. Naturally, in all arid regions there is an abundance of sunshine. This continuous sunshine, together with the proper moisture content in the soil from irrigation, greatly stimulates plant life. In this way irrigation affords almost ideal conditions for agriculture.

Sources of Water. The success of any irrigation project depends upon the availability of an abundant supply of

Correct irrigation insures high production: a Kansas alfalfa field.

water at all times. Water for irrigation may be secured by diversion from perennial streams and lakes; by the storage of flood water from natural watercourses; and by the use of underground waters secured by mechanical methods.

Irrigation Systems. There are two general systems of irrigation: gravity systems and mechanical systems.

Gravity Systems. Gravity systems of irrigation are more extensively used. Such a system consists primarily of headworks for the proper diversion of the water from perennial streams, lakes, or reservoirs, and the distributing system to conduct the water to the land to be irrigated.

The headworks consist of proper gates and appliances to permit regulation of the flow of water into the distributing system. Usually a dam or a diversion weir is constructed in the stream channel to raise the level of the water to such a height that it will enter the gates. The early irrigators used sacks of sand, placed in the stream beds, to form dams, but as water has become more valuable large sums of money have been invested in substantial and permanent headworks to divert and regulate the stream flow. Not only must these headworks be constructed to divert the water properly, but they must be strong enough to resist the force of extreme flood conditions, to which all mountain streams are subject.

The distributing system begins at the headworks. It consists of canals of proper dimension so located as to give a natural flow of water over all the lands to be irrigated. In order to bring this water to the lands it is necessary to carry it to a higher elevation than it would have if it followed the natural stream bed. This is accomplished by carrying the canal systems along the foot of the hills on the sides of the river valley. These canals do not have so steep a slope, or grade, as the natural stream bed. For example, if a river has a fall of ten feet to the mile, the water can be diverted into a canal system with a fall of one foot a mile, and at the end of ten miles the water in the canal system will be ninety feet higher than the water in the stream bed. By carrying the canals along the bases of the hills on the side of a valley, vast areas of productive land can be irrigated. The ditches are constructed in earth or rock in much the same manner as drainage ditches. The irrigation canal must, however, be so located as to conduct the water away from a larger stream, the branches, or laterals, of the canal system gradually carrying smaller quantities of water. The main canals conduct the water to

the laterals, while the laterals conduct the water to the farmers' ditches for final distribution to the fields.

Mechanical Systems. Where water can not be secured from a stream or a lake by natural fall, some mechanical

A lateral carrying water to a distant part of the field.

method is required to lift the water upon the land to be irrigated. This is usually accomplished by means of pumps and engines. Irrigation by pumping is becoming more and more popular each year. The water may be secured from streams or lakes, or from wells penetrating the underlying strata of water-bearing sand and gravel. Irrigation by mechanical methods is important, because it insures the development of vast areas of arid lands in regions where gravity systems would not be practicable. Naturally such irrigation systems are very flexible, and a few acres or several thousand acres may be watered as one regulates the size of the pumping unit. Mechanical systems of irrigation are not so reliable, however, as well-

designed gravity systems. In order to be dependable, the mechanical devices for irrigation by pumping must be of the very best type of standard construction. In different parts of Kansas water for mechanical irrigation may be pumped from streams or from underlying water-bearing strata.

WINDMILL IRRIGATION

The windmill is used extensively for pumping water to irrigate small areas of land about the farm home. Wind-

Pumping underground water for irrigation.

mills have been improved during recent years, and are now readily obtainable from dealers in agricultural implements. It is necessary to select windmills of compact and simple construction, and preferably such as have gained a reputation by actual performance under average agricultural conditions. Where windmills are used to pump the water it is necessary to have adequate water storage to carry the crops through periods when the wind does not blow. It is economical to have a storage tank to accumulate a supply, or head, of water which can be used to advantage when turned upon the land. The average windmill will not irrigate much more than one-half to

three-fourths of an acre. The cost of windmill plants would be excessive where large areas must be watered, but for small farm gardens and lawns the windmill plant affords an economical and convenient method of supplying water.

The Head of Water. The volume of water used to irrigate land is known as the head of water. Where only small quantities of water are available, it is necessary for the farmer to irrigate with small irrigation heads. Where, on the other hand, the quantity of water is large, the farmer can irrigate with high heads of water. In some irrigation districts as much as fifteen cubic feet of water a second is available for the farmer when he is ready to irrigate. This is regarded as a very high head of water.

Pumping underground water with a windmill and storing the water in an earth reservoir. This method is adapted to irrigating small areas.

The Duty of Water. "The duty of water" is a term usually applied to the quantity of water required to mature a crop. It is also used to refer to the area of land which a given flow of water will irrigate during a season.

LOSSES OF WATER

Seepage. It is impossible to apply water to the soil without losses. In the first place, earth canals are not

absolutely water-tight. Part of the water will percolate into the soil and seep away. This loss is known as seepage.

Deep Percolation. When water is applied to the soil in too great a quantity a portion of it will percolate to a depth beyond the root zone of the plant to be grown. This water is beyond the control of the irrigator, and consequently must be regarded as a loss. The process is known as deep percolation.

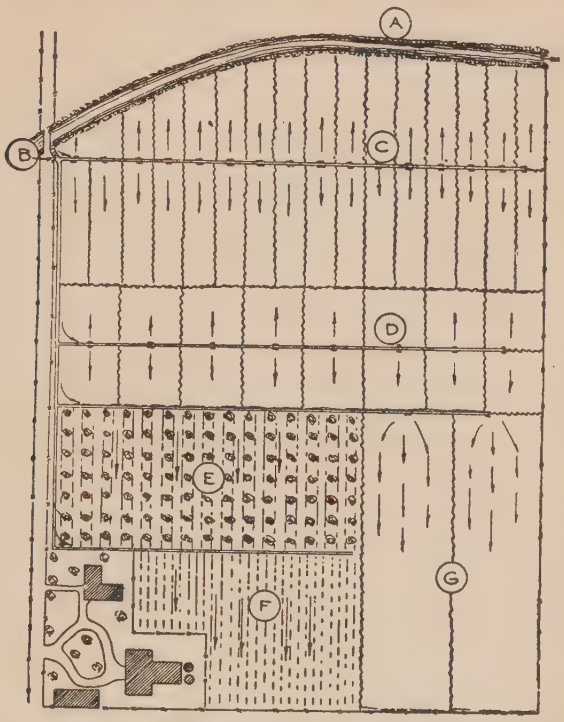
Evaporation. There is always some evaporation when water surface is exposed to the air. From the time when the water enters the head gate of the canal system until the time when it is applied to the crops there is considerable exposure of the surface of the water to the air, and consequently there must be more or less evaporation. This evaporation can be controlled only by running the water through closed ditches. The expense of this is too great in comparison with the amount of water saved, and consequently evaporation in ditches is a loss which must be considered, but which can not be economically remedied. Evaporation of water from the soil following an irrigation may be reduced by proper tillage.

THE PREPARATION OF THE LAND

Ideal irrigation is a thorough and even application of the water to all parts of the field. This can not be obtained when the surface of the land is uneven, since the natural tendency of water is to seek a common level; accordingly, certain portions of the field will receive too much water, while other parts will receive scarcely any. The irrigator must, therefore, level the land so that the water can be efficiently and evenly distributed to all parts of the field.

The Application of Water. An important step in securing a high duty of water is to select correct methods of applying the water. There are four principal methods of

irrigating land by applying water to the surface: wild flooding; flooding within borders; irrigation by furrows;



Sketch showing typical irrigation systems for a small farm. *A*, Irrigation canal. *B*, Farmer's head gate. *C*, Strip check system of irrigation. *D*, Square check system. *E*, Orchard irrigation by furrows. *F*, Furrow irrigation for field crops. *G*, Border irrigation.

irrigation by checks. In addition to this, water is occasionally applied to the soil by other methods, known as subirrigation and sprinkling.

Wild Flooding. By means of the wild flooding method, the water is run down the slope of the land in sheets flowing from the supply, or head, ditches. These sheets of

water overlap or cross one another as they flow across the field. This method of water distribution requires comparatively little labor and is applicable to such crops as wheat, oats, and the grasses. It is not a perfect system, as the water can not be spread evenly over the field. The lands nearest the lateral ditches are liable to receive too much water, while the lower ends of the field are likely to get too little, or, if enough water is permitted to flow to the lower end, provision must be made for the necessary waste of water. This method of irrigation can be successfully used only on sloping land that will not wash.

Border Irrigation. Where the border method of irrigation is used the water is run in the direction of the slope, over the ground to be irrigated. This method permits the use of large heads of water, and the ground is irrigated uniformly between the ridges; but this method is likely to result in over-irrigation at the upper end of the field and under-irrigation at the lower end, unless a large amount of water is applied and provision is made for a considerable part of the water to run to waste. The length of run for the water depends upon the character of the soil and the quantity of water used for irrigation. Fairly porous soils require, for economy of water, comparatively short runs.

Furrow Irrigation. Where furrow irrigation is practiced small depressions are plowed out across the ground to be irrigated, in the direction of the slope, and the water is permitted to run down these furrows for a sufficient length of time to soak the ground thoroughly. This method of irrigation does not require a large amount of work on the part of the irrigator, and the losses from evaporation and seepage are not very great if the furrow is not too long. In most cases the length of the furrow should not exceed

five hundred feet. Furrow irrigation is especially adapted to crops which are cultivated, such as sugar beets, potatoes, corn, and orchard fruits. In some cases, however, fields which are planted to alfalfa are corrugated, or little fur-

Furrow irrigation for root crops.

rows are pressed into the surface by special machinery, and in this way furrow irrigation can be practiced for sown crops.

The Check System. The check system of irrigation is used extensively. The field is marked off into a series of level plats surrounded by little ridges, or dikes, and into these plats the water is run to the required depth for irrigation. This method can be used on practically all kinds of crops, but is especially adapted to alfalfa, wheat, barley, and other non-cultivated sown crops. Considerable work is required to prepare the land to receive the water, but when the land has been properly prepared this method of irrigation requires little effort, and few unavoidable losses of water occur. The size of the check varies with the character of the soil to be

irrigated. Porous, open, and sandy soils should have small checks, while the heavier soils can be successfully irrigated by larger checks. No check should contain more than one and one-fourth acres of land, and usually checks should vary from fifty to one hundred feet in width and from three hundred to five hundred feet in length.

Subirrigation. The introduction of water into the soil by means of underground pipes is known as subirrigation. Subirrigation is, theoretically, an ideal system of water distribution, but unless the soil conditions are ideal the water will not spread very far laterally from the sides of the pipe line. Experience indicates that the underground pipes should be placed from twelve to sixteen inches deep and in parallel lines from six to eight feet apart. The cost of placing these pipes beneath the surface of the ground makes this method of water distribution practically prohibitive except for small areas.

An earth reservoir used for storing water for irrigation. To the right is a main ditch leading to the field.

Sprinkling. Valuable sprinkling systems of irrigation have been devised for the irrigation of vegetables and plants. Sprinkling more nearly approaches the conditions of natural rainfall than does any other system of irrigation.

It requires, however, proper appliances above the surface of the ground in order to distribute the water over the area to be irrigated. Consequently such systems of irrigation are not suitable except for truck farming and for greenhouse use.

THE AMOUNT OF WATER TO USE

Water losses may be reduced by using proper heads of water for irrigation. Sandy, open, and porous lands must be irrigated with high heads of water, otherwise the losses through seepage and deep percolation will be excessive. On heavier lands where the subsoil is rather compact, smaller heads of water may be used.

The irrigator must use good judgment in the amount of water to apply and the time to apply it. Loam and clay loam soils have the capacity of holding in suspension large quantities of water. Such soils do not require frequent irrigations, but a considerable quantity of water can be applied at one time. On the other hand, soils that are gravelly and sandy hold very little water in suspension, and upon such lands frequent small applications of water are necessary to produce maximum yields. The irrigation farmer must study his soil conditions, and his experience in handling the water should guide him in determining the proper amount to apply to the soil and the proper time to apply the water.

CULTIVATION

The successful irrigator must of necessity be a good dry-land farmer. In order to make irrigation really profitable and reliable, just enough water must be used to promote the healthy growth of plant life. If the greatest good is to be secured from the available water supply, the irrigator must also practice careful cultivation. Proper cultivation

prevents undue losses from evaporation, and the stirring of the soil promotes the healthy growth of plants. It may be in some cases cheaper to apply water than to cultivate, but the excessive use of water is usually followed by evil results to the land. Many thousands of acres of land in the arid sections of the United States are in an unproductive condition because of saturation due to seepage from canals and over-application of water to the crops. Such soils require artificial drainage in order to make them productive. Irrigation farming requires the application of the very best principles of farming, as well as careful business judgment on the part of the irrigator.

QUESTIONS

1. Define irrigation. Why is irrigation often necessary?
2. Give some of the advantages of irrigation.
3. From what three general sources may water be secured for irrigation?
4. How may irrigation systems be classified?
5. Of what does a gravity system of irrigation consist?
6. What conditions are necessary for mechanical systems of irrigation?
7. Under what circumstances may windmills be used for irrigation?
8. Why is a reservoir necessary for a sucessful windmill irrigation plant?
9. What is meant by the term, "head of water"?
10. How may water be lost in irrigation ditches?
11. What do you understand by deep percolation?
12. Name and describe four principal methods of irrigating land.
13. To what extent is subirrigation applicable as a means of water distribution? To what extent is sprinkling applicable?
14. What factors are to be considered in regulating the quantity of water to apply?
15. Show the importance of cultivation in connection with irrigation.

CHAPTER XX

FEEDING FARM ANIMALS

Plants the Source of Animal Food. Plants are the sole source of animal food. Without plants animals could not live. Some animals eat the flesh of other animals and of birds, but the food even of these may be traced back to plants. When man eats beef or pork, he is eating plants that have been changed into animal flesh. The plant, therefore, is of fundamental importance to the farmer who raises cattle, horses, sheep, hogs, and poultry. He must grow plenty of plants, such as corn, sorghum, alfalfa, wheat, oats, and grass, to furnish food for his farm animals. There must also be a variety to supply the needs of the animals. When an animal grows, works, or fattens, it needs food in larger quantity than that used when it is idle. Some plants are especially adapted to producing growth. Others are better suited to making fat or to giving the animal strength to do work. Some plants are eaten green, as pasture grass; others are cured to make hay. Many plants produce seed, and in plants like corn, wheat, and oats the seed is the most valuable part for animal food. Feeds such as bran, shorts, cottonseed meal, and flaxseed meal are by-products of mills and factories. The feeder must work out the combination of these feeds that best meets the animal's needs, and then so prepare the feeds that the animal may get the greatest benefit.

USES OF ANIMAL FOODS

Maintenance. Animal foods have two general uses. First, the animal must have enough food to keep all the

vital organs of its body working, to keep it warm, and to give it enough strength to move about in search of food and water. The amount of food necessary for these purposes depends somewhat upon the conditions under which the animal lives. When kept in a comfortable stable, with water and feed supplied, it does not require so much for warmth and strength as when it has to search for food in large fields or pastures where it is exposed to rain and cold.

Growth and Fattening. Second, any food that is left after the needs for existence have been supplied will be used to build up the body or to do work. If the animal is young it is likely to use the additional food for growth of muscle, bone, skin, and other tissue. If the animal is fully grown, it will make the surplus feed into fat, which is stored in the body to be used for maintenance in case of scarcity of feed. Therefore, when a fat animal does not have enough feed it will use its body fat for heat energy, and thus will soon become thin. By the time its fat is gone, and it is getting weak on account of the lack of food, the snow which has covered the food may have melted, or the drouth may have been broken by rains, and the green grass may be springing up again to supply the animal's needs. Thus the animal that is fat may live through snow or drouth, while the animal that is thin may die of starvation before relief comes. Nature gives animals this power to store up food and energy to be used in a time of need, and man is now making use of nature's gift for his own support. The farmer furnishes his animals with an abundance of feed, and they grow and become fat. The fat, with the muscles, makes the cuts of meat thick, juicy, and tender.

Work. When a horse works he may have an abundant supply of food, yet does not put on fat. He is using his

extra food for energy to do work. If the work is hard, like plowing or hauling heavy loads, the feed must be increased to supply the energy needed, or the animal will use his body fat to furnish energy and will soon become thin and lose strength. Therefore the farmer makes use of the animal's power to change surplus food into energy.

Milk. When a cow is producing milk she may have an abundance of feed, yet does not become fat. She, like the horse, is using her surplus food for another purpose—not work, however, but the production of milk.

Uses. The first use of food, maintenance, is in running the animal machine. The second use of food may be divided into a number of production purposes, such as growth, work, and the production of fat, milk, eggs, and wool. Maintenance must always come first, because the animal, like an engine, must be in running order before it can do work. When only a small amount of coal is supplied to the engine it will produce just enough power or energy, in the form of steam, to turn its own wheels; but if given an abundance of coal it will have enough energy to turn the wheels of the threshing machine or the mill. The animal can not do work or produce muscle, fat, or milk until it first has enough feed to move the wheels of life. Food supplied in addition to the amount required for the maintenance of the body will be used for production.

KINDS OF FEED

Concentrates and Roughages. There are many kinds of animal feeds, which in general, however, may be divided into two classes: first, those rich feeds, such as corn, oats and kafir, which furnish an abundance of nourishment with little waste; second, those rough feeds, such as hay,

fodder, and straw, which do not furnish so much nourishment but contain a great deal of material which the animal can not digest. The members of the first group are called concentrates, because they are rich in food material and are easily digested by the animal, while the members of the second are called roughages on account of their coarse nature, which makes them hard to digest. When hay, fodder, or straw is eaten it must be well chewed in preparation for swallowing. When these feeds are very hard and dry this process consumes much energy, and the animal must use some of the valuable part of his feed to produce this energy. If the feeds do not require so much grinding and are easily digested the energy will be used for some other purpose, such as making growth or fat or performing work for the farmer.

Feeding Value. Concentrates have a high feeding value, while roughages have a comparatively low feeding value. Some roughages, such as corn stover or wheat straw, are very low in food value, being woody and rough; while others, such as alfalfa and clover hay, with their many fine leaves and stems, are tender, and have a high food value, almost equal to that of some of the concentrates. In plants such as clover and alfalfa, which produce very small seeds, the greater part of the plant food remains in the leaves and stems instead of making seed as in corn and wheat. When these plants are to be cured as hay they are cut before the seed is formed, which plan allows all of the food to remain in the stems and leaves, thus making a rich, nutritious hay.

THE COMPOSITION OF FEEDS

Feeds of different kinds are made up of different food materials called nutrients. Some of these food materials or nutrients may make up the greater part of a plant or

feed, while others may be almost entirely absent. Then, in another plant or feed there may be found an abundance of nutrients which were lacking in the first plant or feed.

The Composition of Animal Bodies. One can better understand the needs of animals if one knows something of the composition of their bodies. Animal bodies are composed of water, protein, fat, ash, and a very small amount of carbohydrate material. This is very similar to the composition of plants, except that plants contain an abundance of carbohydrates, while animals have a larger amount of fat. When the animal tears down plant carbohydrates, it does not rebuild them into animal carbohydrates, but uses them for fat, heat, or work. Young animals, as a rule, have less stored fat, and therefore will die of starvation sooner than mature animals. Their bodies contain a larger proportion of water and muscle tissue, and their demands are for growth-producing nutrients, such as protein and ash, while the bodies of mature animals demand foods more suitable for maintenance, fat, and work.

THE DIGESTION OF FEEDS

The Purpose of Digestion. Before food can be used in the animal body it must undergo the processes of digestion. These processes make the nutrients soluble, so that they may be carried by the blood to different parts of the body, where they are used. The animal during digestion tears down the food which was so carefully built up and stored in the plant. It then rebuilds the food into body tissue, or may use it for heat or work.

Work Done in the Mouth. In most farm animals the first step in the processes of digestion takes place in the mouth, where the food is ground and moistened with saliva. The saliva acts on a part of the starch in the

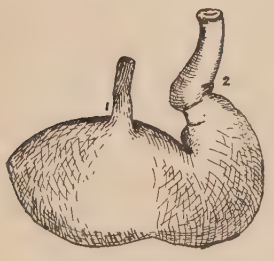
food, changing it to sugar, which is soluble and easily absorbed into the body when it reaches the intestines.

Work Done in the Stomach. After the food is thoroughly ground and moistened to be swallowed, it passes to the stomach, where further digestion takes place. Here some of the protein nutrients are attacked by the digestive juices secreted by the stomach, and are broken down into soluble forms so that they may be absorbed and carried by the blood to parts of the body that need material for growth or repair.

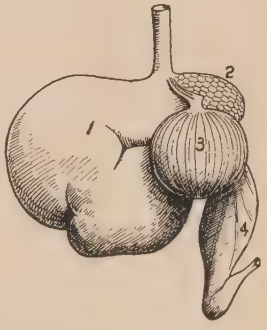
Work Done in the Intestines. After the food has been churned about in the stomach for some time, allowing the juices to break down nutrients, it passes to the intestines, where the fats are digested and where most of the broken-down nutrients are absorbed by the blood and lymph, to be transported to all parts of the body. Some of the coarse, woody part of the feed passes on as waste because the digestive juices are not able to break it down.

Differences in Digestive Tracts of Animals. The digestive tracts of farm animals differ widely, some of them being adapted to the digestion of rough feeds, while others must have the greater part of their food supply in the form of concentrates. Because of their stomach capacity, cattle, sheep, and goats are able to digest large quantities of rough feeds. Each of these animals has four stomachs through which the feed passes during digestion First, the feed is eaten hurriedly and stored in the first stomach, which is very large and is called the paunch. After the food is mixed somewhat in the first and second stomachs, it is returned to the mouth in the form of balls, to be chewed. The regrinding takes place while the animal rests, and we say the animal is chewing its cud. The horse has only one small stomach, but, on account

of large intestines, and a pouch called the cæcum, it can digest rough feeds, such as hay and straw. It does not, however, digest these feeds so thoroughly as does the cow,



Stomach of horse: 1. Cardiac end. 2, Pyloric end.



Stomachs of cow: 1, Rumen, or paunch, showing attachment of the esophagus; 2, reticulum; 3, omasum, or manyplies; 4, abomasum, or digestive stomach, showing attachment of the small intestine.

and hence requires more concentrates, such as corn and oats. The pig has a small stomach and small intestines, which fact requires that the greater part of its ration be made up of grain or other concentrated feed. Such rough feeds as alfalfa and clover hay, which have a high food value and many fine stems and leaves, are relished by hogs, and may be made to supply a large part of the sow's ration during winter months, when she is not producing milk for her pigs. Hogs that are being fattened must have an abundance of concentrates and little or no roughage. Cattle, sheep, and goats live on rough feeds alone, but if they are being fattened, plenty of concentrates, such as corn, wheat, kafir, and barley, must be added to the roughage to supply an abundance of nutrients which are easily digested.

The following table* will give a good idea as to the capacity of the digestive organs of farm animals:

Capacity of stomach and intestines.	Quarts.	Length of intestines.	Feet.
HORSE—			
Stomach	19.0	Small	73.6
Intestines	204.8	Large	24.5
	223.8		98.1
OX—			
All four stomachs	266.9	Small	150.9
Intestines	109.8	Large	36.3
	376.7		187.2
SHEEP—			
All four stomachs	31.3	Small	85.9
Intestines	15.4	Large	21.4
	46.7		107.3
HOG—			
Stomach	8.5	Small	60.0
Intestines	20.5	Large	17.1
	29.0		77.1

Kinds of Nutrients and their Uses. The food nutrients may be divided into two general classes, according to their uses by the animal: those which produce growth and repair; those which produce fat and energy. The first are called protein material; the second, carbohydrates and fats. All plants are made up of protein, carbohydrates, fats, water, and material called mineral matter, or ash. The animal uses mineral matter, or ash, chiefly to make bone. Ash is also used in small amounts in the blood, digestive juices, and other soft parts of the body. Except in rare cases, the demand by the animal for mineral matter is not greater than the supply; the farmer therefore is not so much concerned with furnishing this material as with furnishing sufficient amounts of protein to meet the needs of growth and repair, or of carbohydrates and fats to produce heat, energy, and fat.

* Henry's *Feeds and Feeding*, p. 19.

The Nutritive Value of Feeds. Corn, wheat, barley, and kafir are fattening feeds because they contain a large amount of carbohydrates, such as starch and sugar; some fat in the form of oil; and a comparatively small amount of protein. Alfalfa, clover, bran, shorts, and milk are growth-producing feeds, since they contain comparatively large amounts of protein, which is essential to growth. The fattening feeds contain some protein. In feeding corn, however, as there is not enough protein, or growth-producing nutrients, to meet the needs of the young animal, it is necessary for the farmer to supply protein by adding to the corn some feed, like skim milk or alfalfa, which is rich in protein material. Often the farmer does not produce enough protein feeds to supply the needs of his animals, and it is necessary for him to buy such feeds as cottonseed meal, linseed meal, shorts, meat meal, and tankage to add to his fattening feeds, in order that his live stock may grow into profitable animals.

Following is a list of some of the most common feeds, classified according to their composition—those rich in protein and hence suitable for the production of growth, and those rich in carbohydrates and fat and therefore suitable for maintenance or for fattening:

Protein feeds.	Carbohydrate feeds.
Alfalfa hay.	Corn.
Clover hay.	Wheat.
Vetch hay.	Barley.
Wheat bran.	Oats.
Wheat shorts.	Rye.
Linseed meal.	Kafir.
Cottonseed meal.	Milo.
Whole milk.	Sweet sorghum.
Skim milk.	Hominy feed.
Cowpeas.	Molasses.
Soy beans.	Beets.
Gluten meal.	Silage.

Protein feeds.	Carboh ydrate feeds.
Gluten feed.	Corn fodder.
Distillers' grains (dried).	Corn stover.
Brewers' grains (dried).	Timothy hay.
Oat middlings.	Prairie hay.
Tankage.	Millet.
Meat scraps.	Oat straw.
Germ-oil meal.	Wheat straw.

NEEDS OF THE ANIMAL

The Ration. The amount of feed given an animal in a day is called a ration. This ration may be sufficient in amount and composition to meet all the needs of the animal, or it may be a starvation ration. If it meets all the requirements of the animal without waste of nutrients, it is called a balanced ration. The animal, like man, relishes its ration more if there is a variety, and especially if part of the food is green, or fresh. By mixing the feeds the ration may be made to taste better, and the animal will eat more. Moreover, mixing protein feeds and carbohydrate feeds permits the making of a balanced ration, or one which supplies the needs of the animal, whether for maintenance or growth, fat or work.

Carcasses of two hogs the same age. The small hog was fed only corn. The large hog was fed corn and alfalfa.

The Effect of Different Rations. The accompanying illustrations show some of the needs of animals. The first photograph shows the effect of feeding young pigs with corn alone and with corn and alfalfa. The pigs were given all they would eat in each case. The small pig received corn and water. He grew very slowly and did not relish his feed. The large pig ate a mixture of corn and alfalfa. He kept a good appetite and made a rapid growth. The alfalfa supplied the protein for growth which the corn

Steers two years old. They were fed the same kind of feed from birth. The small steer was allowed only enough for maintenance, while the large steer had all he would eat.

lacked. Unless the carbohydrates and fat are supplied as needed, the animal will not grow as it should. If there is a deficiency of protein the animal will remain small and thin, like the pig which ate corn alone. If no protein is supplied in the feed the animal will soon die, because the protein in his body will waste away. This shows how vitally important the protein nutrients are to the animal.

The Amount of Feed. In many cases animals have the right kind of feed for growth, but are not fed enough to supply their needs. The accompanying picture shows two steers of the same age. The large one has had plenty of the right kind of feed all his life, while the small one has had the same kind of feed, but barely enough of it to keep

him alive. He had enough for maintenance, but none for production. The large steer weighs 1250 pounds; the small one, 227 pounds.

The Feeder's Duty. Now it is evident that the farmer must do at least three things in feeding live stock. First, he must so prepare the feed that the animal will relish it. Second, he must supply his animals with protein and carbohydrates in the right proportions. Third, he must feed his animals enough to meet their needs.

THE PREPARATION OF FEEDS

Often we may help the animal to digest its feed more thoroughly by grinding, crushing, or soaking the feed. Small seeds, like wheat, rye, barley, kafir, milo, sorghum, and millet, are very hard, and if they are swallowed without much chewing, the digestive juices can not penetrate their hard coverings to break down their nutrients, and they pass on undigested, just as does the coarse, woody material which the juices can not digest. This waste of food may be prevented by grinding or by soaking to make digestion easy, but often this does not pay if the cost of grinding is very high. If we know that six per cent of the food value of corn can be saved for the pigs by grinding and that the grinding costs three cents a bushel, we can figure when it will pay the farmer to grind his corn for hogs. If his corn costs forty cents a bushel he will lose by grinding it. If the price is fifty cents, he will come out even. If, however, the price is above fifty cents, the grinding will pay, and the higher the price the larger the profit in grinding. The more valuable the feeds, the better can we afford to prepare them for easy digestion and to make them palatable. Cooking feeds sometimes makes them more palatable for the animal, but cooking is expensive and lowers the feeding value of

the protein nutrients. Therefore it does not pay, except in a very few cases. Feeds that are already palatable and feeds that are rich in protein should not be cooked for animals. Soaking feeds, especially the small, hard grains, makes them more easily digested and is inexpensive.

If soaked feeds are allowed to stand during warm weather they become sour, and may be injurious to animals, especially young animals. Care should be used in feeding such feeds, as in any case where the feed is damaged. Moldy feeds are injurious to most animals, and particularly to horses. Such feeds should not be used at all if badly damaged. Cattle will eat them with less danger than other animals. When farm animals are using feed for production purposes it often pays to prepare the feed by grinding, crushing, chopping, or soaking it. The animal is allowed to save energy in digesting its feed, and the feed will be used for growth, work, milk, or fat. If the animal is idle, it may well afford to grind its own feed, and some of the cheaper rough feeds will supply its needs quite as well as the higher-priced concentrates which are so valuable for production purposes.

QUESTIONS

1. What parts of the common farm plants are used by animals? Which parts are most valuable for feed?

2. Distinguish between concentrates and roughages and give five examples of each. Give two reasons why roughages have a lower feeding value than concentrates.

3. Name the uses of digested feed in the animal body. What demands of the animal body must first be supplied when feed is consumed?

4. Why does an animal put fat on its body when it has an extra supply of feed? Is this of economic importance? Explain.

5. Explain why an animal becomes thin when doing very hard work.

6. What are nutrients?

7. What is the greatest use of mineral matter in the animal body?

8. What is a ration? Why should balanced rations be fed?

9. Compare, in effect on the development of young animals, a ration low in protein with a ration containing a liberal amount of protein.

10. What are the advantages of making the animal's ration palatable?

11. What can the feeder do to aid in securing maximum growth in his live stock? Give reasons for your answer.

12. Does the animal obtain all of its body fat from the fats in its feed? If not, what are the other sources of body fat?

13. State the purpose of digestion. In what parts of the body does digestion take place?

14. Why are cattle better able than horses to live on corn fodder and wheat straw? Explain fully.

15. What effect does the price of a feed have on the care that should be used in preparing it for the animal? What are the objections to cooking feeds for animals?

CHAPTER XXI

HORSE PRODUCTION

The Kansas climate is well adapted to the production of horses. There exists to-day, in the city and on the farm, a demand for high-class horses. This demand can not be supplied, because there are very few horses of this kind in the country. At the same time, both market and country are overstocked with inferior horses, for which there is no particular demand.

Recent statistics show that Kansas owners have approximately $150,000,000 invested in horses and mules, as against $106,500,000 invested in all other classes of live stock combined. This means that these owners have approximately forty per cent more money invested in horse stock than in all other stock, yet less attention and study has been given to profitable horse production than to the production of any other kind of animal.

THE ORIGIN OF THE HORSE

The Prehistoric Horse. It is well known that horses existed in all parts of the world long before history was written. There are marked differences, however, between the early animal and the present-day horse. The early horse resembled a dog more than a horse, being probably a foot in height, and having four well-developed toes and one partly developed toe on each front foot, and three well-developed toes and one partly developed toe on each hind foot. The horse of to-day has reached its present state of development largely by adapting itself to a gradually changing climate through

centuries, and by means of the improvements made by man through careful selections in breeding and through proper feed and protection.

The Modern Horse. Horses were not used for work in early times, but were worshipped and were ridden in war. For three thousand years after the horse was domesticated (2080 B. C. to 1066 A. D.), it was used very little, if at all, for any other purposes. During the year 1066 A. D., the horse was first used as a farm animal, and from that day to the present it has been constantly used both for farm work and for hauling loads. In the earliest history of the modern horse are described several distinct types. All our present breeds of horses have developed from blending and improving these early types.

Classification of Horses. Horses are classified primarily according to size, type, substance, and quality. Size includes both height and weight. The form of the horse determines the type. Substance is indicated by strength and durability, while quality is determined by refinement of fiber of the animal.

Horses may be classified as follows:

HEAVY SERVICE—
- Draft horses.
- Logging horses.
- Wagon horses.
- Chunks.

RAPID SERVICE—
- Coach, or carriage, horses.
- Park horses.
- Roadster horses.
- Runabout horses.
- Saddle horses.
- Ponies.

BREEDS OF HORSES

Percherons. The Percheron is a breed of draft horses that originated in La Perche, a small district in northern France. This breed was developed by crossing the native

black horses of lowland Europe with horses introduced from Asia about 730 A. D.

Later, when railroads were built, the rapid, light draft horses were no longer in demand, as they had been used principally for stagecoach purposes, and the breed-

A Percheron stallion.

ers of La Perche, with keen foresight, saw in the future a need and a demand for heavy draft horses, and began at once the work of increasing the size and weight of their native horses. The size of the present-day Percheron has been attained by careful selection, intelligent mating, and liberal feeding.

The Percheron is an ideal drafter, not too squatty and not too rangy. A horse of this breed is generally well-made and symmetrical in form, with medium-sized feet of

good quality. It has a bold way of going, though its action is not quite so true and square as that of some other breeds. The most popular colors in Percherons are black and gray. Bays, browns, chestnuts, and roans are not uncommon, but these colors are looked upon with disfavor. The popularity of the Percheron is due to the animal's ability to adapt itself readily to various conditions, and to the satisfactory horses obtained when Percherons are crossed with native American mares. Some of the faults of the Percheron, which breeders are trying to eliminate, are lightness of bone, crooked and meaty hocks, and straight pasterns.

French Draft Horses. There are several other distinct breeds of draft horses that have been developed in France, but none of these is so widely disseminated as the Percheron. An association has been organized in the United States for the purpose of registering the various draft horses of French origin and designating them as French draft horses.

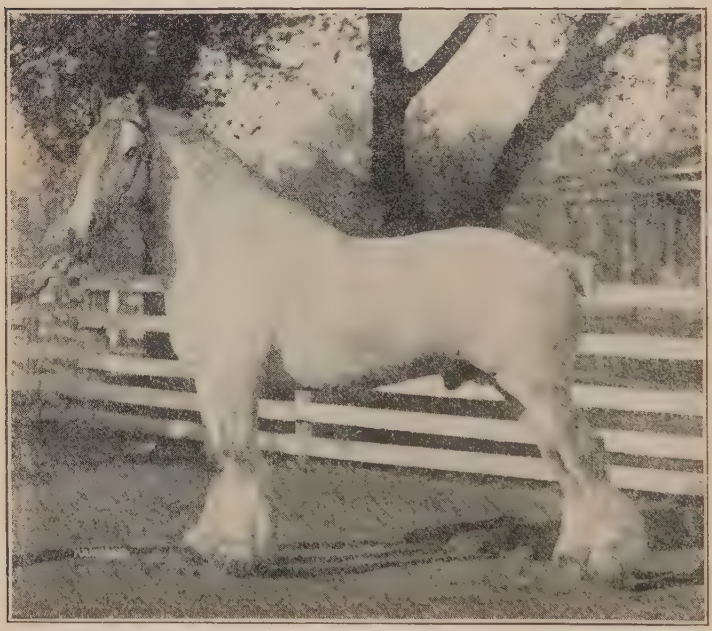
Belgian Draft Horses. Belgian horses have descended from the massive black horse of the Low Countries, and the present-day type is the result of careful selection and feeding. The work of improving the breed of horses has been encouraged by the Belgian government since the middle of the nineteenth century. No other government has taken such keen interest in improving its horses or has been more liberal in its appropriations for this work. Belgian horses are more massive and more compactly built than Percherons. They are noted for their excellent middles, and for their easy keeping qualities. The principal colors are chestnut, roan, and bay. Brown is not an uncommon color. Occasionally one sees a black or a gray. Belgians mate well with ordinary farm horses,

and their popularity is increasing very rapidly. The Belgian horse has been criticised for being a bit low in the back, somewhat squatty, and steep in the croup, and having poor feet, but the Belgian breeders are overcoming these faults very rapidly.

A Belgian mare.

Shire Horses. The Shire horse has been known by various names, of which perhaps the most common is "English Cart Horse." It is generally thought that the Shire originated from crossing the black horses of lowland Europe upon the native horses of England at intervals for several centuries. The present-day Shire, as a breed, is the most massive of all draft horses. Shires have a very heavy growth of hair—feather, as it is designated by horsemen—on the leg from knee to hoof. The principal

colors are bay and brown, although many other colors are not uncommon, particularly chestnut and black, or even gray or roan. White markings on face and legs are rather common. The average Shire horses imported to this



A Shire stallion.

country are not the best representatives of the breed, and may be criticised as a bit coarse, straight of pastern, and flat of foot, and as having too much hair on the legs.

Clydesdales. The Clydesdale originated along the river Clyde in Scotland. The black horse of the Low Countries, later known as the Flemish horse, had considerable to do with the origin of the Clydesdale. Later, Shires of quality were used occasionally. The Clydesdale

of to-day is not so massive as the Shire, the Belgian, or the Percheron, but shows truer and snappier action and higher quality than any other breed of draft horses. Clydesdales have considerable hair on the leg below the

A Clydesdale mare.

knee, but it is much finer and not so plentiful as in the case of Shires. Bay and brown are the most common colors, although chestnut, black, and roan are not uncommon. White markings on face and legs are characteristic of the breed.

Suffolks. The Suffolk has been bred absolutely pure for a longer period than any other breed of draft horses. It is a native of Suffolk, in eastern England. Suffolks are noted for their good disposition and their easy keeping qualities. They are always chestnut in color. This breed

is not widely distributed, principally because it does not have the size demanded of present-day horses.

Hackneys. The Hackney originated in Norfolk and adjoining counties in eastern England. It is the most popular of all coach or carriage breeds. Hackneys vary in height from 15 to 15¾ hands, and are compactly built harness horses, with broad, full chests, short backs, long, level croups, and full middles. Chestnut color, with white feet, is most common and most popular. Bays, browns, and blacks are not uncommon.

German Coach Horses. The German Coach horse is the largest of all coach breeds, and is the result of the efforts of the German government to produce an army horse. Considerable variation of type, quality, and action is noted in this breed. While some horses of this breed show considerable quality and flashy action, they may, as a rule, be criticised for lacking these qualities. The common colors are bay, brown, and black, with very little, if any, white. German Coach horses vary in weight from 1200 pounds to 1500 pounds.

French Coach Horses. The French government also endeavored to develop an army horse, and the French Coach horse is the result. The French Coach horse is smaller and more refined than the German Coach, but is larger than the Hackney and lacks the quality and finish of that breed. Generally speaking, the French Coach horse has not been a satisfactory horse in this country. The common colors are bay, chestnut, and brown, with usually more than one white foot, but seldom more than three.

Other Coach Horses. Other coach horses are the Cleveland Bay and the Yorkshire, both of which originated in northeast England.

Standard-bred Horses. Standard-bred horses are an American product. Most trotters and pacers of this country are Standard-breds or grades of the breed.

The Standard-bred horse of to-day originated from three principal sources: Messenger, a Thoroughbred imported from England in 1788; Justin Morgan, a noted horse of Thoroughbred origin foaled in Massachusetts in 1789; and Jary's Bellfounder, a Hackney imported to America in 1822. We have to-day the trotter and the pacer of extreme speed and endurance as a result of careful and intelligent selection of horses descending from these three foundation horses of the breed. During the early period in the formation of this breed, several noted families were developed, the most important being the Hambletonian, the Mambrino Chief, the Pilot, the Clay, the Hal, and the Morgan.

Standard-bred horses are more slender in build than coach horses, having clean, slender, well-set necks and very deep chests. The Standard-bred is the ideal roadster horse. As a breed, it may be criticised for lacking somewhat in size and uniformity of type. This is due largely to the fact that breeders in seeking speed have not given due consideration to some of the other qualities a good horse should possess. Good Standard-bred horses vary in weight from 1000 pounds to 1200 pounds, and in height from 15 hands to 16¼ hands.

Morgan Horses. Morgan horses are one of the early families of Standard-bred horses which descended from Justin Morgan. They were hardy little horses and served a useful purpose in helping to give endurance and stamina to the Standard-breds as a whole; but, because they were small and usually did not possess much speed, they gradually fell into disfavor and were almost exterminated. An effort is being made to revive interest in Morgan horses.

Orloff Horses. The Orloff is the Russian trotter, which was originated during the latter part of the eighteenth century by crossing Arabian horses on some horses brought from Friesland. Gray and black are the most prevalent colors, but other colors are not uncommon. Orloffs do not have the speed of Standard-breds for distances up to a mile, but are superior for distances of three or four miles.

Arabian Horses. Arabian horses originated in northern Africa, and later found their way to Arabia, where great improvement was made in them. The Arabian horse has had an important part in improving practically all present-day breeds of horses, and this fact constitutes its chief importance. Spotted and odd-colored horses are very often wrongly spoken of as Arabians, but solid bay is the characteristic color, although grays and browns are not uncommon. Arabians are small horses, varying in height from 14 to 14½ hands. They are noted for quality, substance, endurance, beauty, and intelligence.

Similar to the Arabian are the Barb horse of Barbary and the Turk horse of Turkey in Asia. The three breeds are spoken of in horse history as Oriental horses.

Thoroughbreds. "Thoroughbred" is the name of a distinct breed of horses—the running horse. This breed originated in England from a cross of Arabian and other Oriental breeds upon the light native mares of that country during the latter part of the seventeenth and early part of the eighteenth century. Speed on the run or the gallop has been the quality sought exclusively in these horses. The Thoroughbred has been bred pure longer than any of the other modern breeds, and is noted perticularly for its quality, refinement, clean-cut features, and high-strung temperament.

The Thoroughbred has been used to add quality and

refinement to practically every present-day breed—and especially the racing breeds—of horse.

Thoroughbreds vary in weight from 1000 pounds to 1200 pounds, and in height from fifteen hands to sixteen hands. Bay and chestnut are the common colors, although brown, black, white, and gray are not uncommon.

An American Saddle horse.

American Saddle Horses. The American Saddle horse is strictly an American breed, which was developed to its present character in Kentucky, Tennessee, and Missouri. In the early days of Virginia, many Thoroughbreds were brought from England, and, as the settlers pushed westward, travel was principally on foot and on

horseback. The latter method was the one most often preferred. This created a need and a demand for horses of easy gait from among the Thoroughbreds and Thoroughbred crosses of that day.

Careful selection for several generations has developed an easy-gaited saddle horse, into which has been bred a tendency to show several distinct gaits. Hence, it is known not only as the American Saddle horse, but also as the Gaited Saddle horse. The development of the American Saddle horse is an instance where the breeder did not lose sight of the value of symmetry of form, elegance, and quality in his efforts to produce a special-purpose horse, for to-day the American Saddle horse is the most beautiful, most stylish, and most intelligent of horses.

Saddle horses vary in weight from 1000 pounds to 1200 pounds.

Hackney Ponies. Hackney ponies are Hackneys under 14½ hands in height.

Welsh Ponies. Welsh ponies are natives of Wales. Having been developed in the rougher districts of that country, they are rugged little horses, much like coach horses, but smaller. They have considerable speed and rather flashy action. Bay is the prevalent color, although nearly all solid colors occur. The horses vary in height from 12½ hands to 14½ hands.

Shetland Ponies. Shetland ponies are natives of a group of islands about two hundred miles north of Scotland. The islands are rugged, with no trees and a very scanty growth of forage crops. This adverse environment is responsible for the small stature of the ponies.

Shetland ponies should be under forty-two inches

(10½ hands) in height, although a height of forty-six inches is allowed.

FEEDING HORSES

General Suggestions. Regularity should be one of the first considerations in feeding horses. The general health, condition, and spirits of a horse are greatly influenced by regularity in feeding. This is particularly noticeable in work horses. Irregular feeding is neither healthful nor economical.

Usually too much hay is fed to work horses. It is the common cause of heaves. Twelve pounds of hay a day for each thousand pounds of live weight is sufficient under average conditions. One-fourth the daily allowance of hay should be fed in the morning, a very small portion at noon, and the rest at night. Only clean, bright, well-cured hay and grain should be fed to horses. They are more susceptible to digestive disorders than any other class of live stock and should never be fed moldy or musty feed.

The Grain Ration. Corn is an unsatisfactory ration for work horses when it is fed with timothy, prairie, cane, or kafir hay, especially in hot weather. A combination of seven parts of corn, three parts of bran, and one part of linseed meal (proportions by weight) is a very satisfactory grain ration for either growing or work horses when it is fed with timothy, prairie, cane, or kafir hay. This combination is cheaper than either corn or oats used alone as the grain ration.

Oats is a better grain ration than corn for work horses, especially during hot weather.

When corn is fed with the proper amount of alfalfa hay of the right kind and quality, the ration is as satisfactory as one consisting of oats and prairie or timothy hay, and reduces the cost from ten to thirty per cent.

The amount of grain to be fed depends upon the individuality of the horse and the work it performs. For an average horse doing average work, about twelve pounds of grain a day for each thousand pounds of live weight may

Pure-bred draft mares averaging more than 1800 pounds in weight, used for farm work at the Kansas State Agricultural College.

be used as a standard. The grain ration should be increased or decreased in proportion to increase or decrease in the amount of work performed.

The Hay Ration. The principal forms of roughage used in Kansas for horse feeding are timothy, clover, prairie, alfalfa, and sorghum hays. In general, each part of the state has a particular form of roughage. Timothy and clover are grown in the eastern part, prairie hay in the central part, and sorghum hays in the western part, while alfalfa is now grown in practically all parts of the state. Timothy, prairie, and sorghum hays have practically the same feeding values. Clover and alfalfa have similar feeding values. Alfalfa hay is considered a very valuable feed for most classes of live stock, but a strong prejudice exists against its use for horses, particularly work horses. If alfalfa hay is properly fed, it may be fed to any kind of horse. This applies just as strongly to work horses as to growing horses. In order, however, to be fed success-

fully, it must be cut at the proper time, and must be fed as a concentrate rather than as a roughage. It is often said that the proper time to begin cutting alfalfa hay is when the field is about one-tenth in bloom. Cutting at

A two-year-old Percheron filly.

such a time makes very good hay for cattle, but such hay is too "washy" for horses at hard work. To make hay suitable for horses at hard work, the alfalfa must be allowed to get rather mature before cutting. In fact, the field should be in full bloom before the mower is started.

After the hay has been cut at the right time and properly cared for, the next consideration is the amount to be fed daily. Probably the most important cause of so much trouble in feeding alfalfa hay has been overfeeding.

Experience seems to indicate that one and one-fifth pounds of alfalfa hay a day for each one hundred pounds of live weight is about the maximum amount to feed work horses. For best results some other roughage, such as cane, kafir, corn fodder, or prairie hay, should be fed with alfalfa hay.

SOUNDNESS AND UNSOUNDNESS

A horse, to be of the greatest value, must be sound and free from blemishes. Horsemen usually make a distinction between unsoundness and blemishes in their animals. An unsoundness is usually defined as any disease, defect, or condition that actually lessens the usefulness of the animal, while a blemish is anything which injures the appearance of the animal but does not in any manner interfere with its usefulness. In some instances, great care and good judgment are necessary to distinguish between a blemish and an unsoundness. A wire cut, for example, is sometimes only trivial in nature and leaves only a scar which passes as a blemish. Again, a wire cut may injure a joint, causing permanent stiffness or lameness, which would be an unsoundness. Some of the more common blemishes are windgalls, scars from cuts, capped hocks, and small splints.

As regards soundness, horses may be divided into three classes.

1. Sound.
2. Serviceably sound.
3. Unsound.

A sound horse is absolutely free from all blemishes and unsoundnesses.

A serviceably sound horse is free from all unsoundnesses but may possess one or more blemishes. The blemishes present do not in any way interfere with the natural

usefulness of the horse, but may detract more or less from its attractiveness and thereby lessen its market value.

The unsound horse is one which possesses one or more of the various diseases or defects that constitute unsoundnesses.

Temporary Unsoundnesses. Temporary unsoundnesses may be defined as those diseases or defects which diminish the natural usefulness of the animal temporarily, such as disease, sprains, cuts, and bruises, but from which it will probably recover.

Permanent Unsoundnesses. Permanent, or chronic, unsoundnesses are those that permanently interfere with the natural usefulness of the animal so as to make him less capable of doing work. The permanent unsoundnesses are of greatest importance. They may be divided into:

1. Those showing a hereditary tendency to develop in the offspring, such as bone spavin, stringhalt, and tendency toward blindness.

2. Those not showing a hereditary tendency to develop in the offspring, such as poll-evil, fistula of the withers, and sweeny.

The Unsound Horse as a Market Animal. In all markets there is a demand for sound horses; they always sell at a premium. If the producer would make the most of his opportunities and secure the greatest profits from the breeding of horses, he must produce the kind of horses that the markets and the farms demand.

Many instances might be cited to show how severely an unsoundness may affect the value of a horse. Unsoundnesses result in a depreciation of from twenty-five to seventy-five per cent in the market value of an animal, depending upon the class to which it belongs and the quality of the horse aside from the unsoundness

present. It costs just as much to raise an unsound as a sound horse, and it therefore is important that the breeder put forth an earnest effort to eradicate the unsoundnesses which are the cause of so great a loss of money to the horse-breeding industry.

A horse, showing the points mentioned in judging.

1. Muzzle.
2. Nostrils.
3. Forehead.
4. Eyes.
5. Throat.
6. Ears.
7. Crest.
8. Neck.
9. Shoulder.
10. Point of shoulder.
11. Arm.
12. Elbow.
13. Forearm.
14. Knee.
15. Cannon.
16. Ankle.
17. Pastern.
18. Foot.
19. Back.
20. Loin, or coupling.
21. Ribs.
22. Belly.
23. Flank.
24. Croup.
25. Tail.
26. Hips.
27. Gaskin, or lower thigh.
28. Quarter and thigh.
29. Stifle.
30. Gaskin.
31. Hock.
32. Hock.
33. Cannon.
34. Ankle.
35. Pastern.
36. Foot.

JUDGING HORSES

The horse may be looked upon as a machine made up of many parts, each of which serves a particular purpose. When each part of the horse is of the correct size, shape,

and quality, and all parts work in harmony, we have an efficient, serviceable machine, used chiefly for the purpose of pulling either light or heavy loads. If one or more of the many parts of a horse are not of the correct shape, size, or quality, then a weakness exists, and we have a less efficient machine. Sometimes the defect of some part may be so serious as to make the horse useless for the work he should be able to perform. Judging a horse is simply the process of making a careful and systematic examination of all his parts, noting carefully the shape, the size, and the quality of each, and comparing them with those adopted as correct by men of experience.

The Draft Horse. The draft horse, which should weigh at least 1600 pounds and be attractive in appearance, is the great utility horse.

The head of such a horse should be attractive, lean, broad, and large enough to harmonize with the rest of the body. The muzzle (1) should be clean; the nostrils (2) large; the eyes (4) bright, large, and expressive; the forehead (3) full and broad; the throat (5) clean, neat, wide between the jawbones; the ears (6) well set, medium in size.

The neck (8) should have plenty of length and should fit smoothly into the shoulder. The crest (7) should not be too heavy in mares and geldings, but should be very strong in stallions.

The shoulder (9) must be long and sloping, fitting smoothly into the back. There must be plenty of width between the points of the shoulders (10), but the points themselves must not be prominent. The arm (11) should be full and heavily muscled.

The front leg should rest square and plumb and be well muscled in the forearm (13), with a strong, broad, deep, well-supported knee (14). The cannon (15), when

viewed from the side, should have a broad, flat appearance, with the tendons standing out plainly and distinctly. The ankle (16) must be large, strong, and smooth. The pastern (17) should have a slope of approximately forty-five degrees, and should have sufficient length to insure ample spring when the horse walks or trots. The foot (18) should be large, deep, and well-proportioned, the toe being about two and one-fourth times the length of the heel. The foot should be wide at the heel and should have a large, prominent frog and a strong, concave sole. The hoof should have a tough, waxy appearance.

The back (19 and 20) should be short, straight, wide, and well-muscled. The coupling (20) should be short, wide, and powerfully muscled.

The barrel, or middle (21, 22, 23), should be deep and wide, and the lower line almost level. Such a barrel, or middle, results from well-sprung, long ribs and a deep, full flank.

The hips (26) should be wide apart, but smooth and not prominent.

The croup (24) should be long, wide, level, and powerfully muscled. The tail should be set high and be well carried.

The quarter and thigh (28) should be long, deep, broad, and heavily muscled.

The hind legs should rest square and plumb, not too far out behind or too far under the body. The gaskin, or lower thigh, (27) should be strong and well-muscled; the hock (31), straight, long, wide, clean, and well-supported below; the cannon (33), clean, wide, and flat; the ankle (34), smooth and strong; the pastern (35), sloping at an angle of about fifty degrees; and the foot (36), of good quality, large, and well-proportioned

The action should be easy and snappy, rather than

sluggish or slovenly. The stride should be long, straight, and well-balanced.

Light Horses. Light horses, both harness and saddle horses, are, as their name indicates, less massive than draft horses. They are slight of build and light of body, but must have substance and quality in every part.

QUESTIONS

1. How long have horses existed? When was the horse first used as a farm animal? For what purposes was it previously used?
2. Name the principal classes of heavy service horses. Name the principal classes of rapid service horses.
3. Of what country is the Percheron breed a native? What are the popular colors for Percheron horses?
4. Distinguish between a Percheron horse and a French Draft horse.
5. In what respects do Belgian horses differ from Percherons?
6. Of what country is the Shire horse a native? the Clydesdale?
7. In what respects do Shire horses differ from Clydesdale horses?
8. What breed of coach horses is most popular to-day?
9. What was the origin of the Standard-bred horse?
10. What do horsemen mean by the term "Thoroughbred"?
11. Of what value has the Thoroughbred horse been in improving our present breeds of horses?
12. What was the origin of the American Saddle horse?
13. What is the difference between an unsoundness and a blemish?
14. Name three hereditary unsoundnesses. What effect does an unsoundness have upon a market horse?
15. How should hay be fed to a work horse?
16. What cautions should be observed in feeding alfalfa to work horses?

CHAPTER XXII

BEEF CATTLE

Beef production is associated with the best type of farming in every country. No other animal makes such large and profitable use of roughage and grass as does the beef animal; none is so free from disease; none requires less shelter or attendance; none can carry its carcass to market with as great ease; and none enables the farmer to distribute his work so uniformly throughout the year.

The cattlemen of the future must be just as good farmers as those who produce grain and hay for market, and, in addition, must have the ability and judgment to select breeds and to feed animals that can profitably reduce the grain and roughage to a more concentrated product. If the cattlemen possess this ability, they will have four sources of profit; first, growing crops; second, feeding crops; third, the use of otherwise waste material, such as straw, stover, and damaged hay and grain; fourth, increased fertility of the soil and increased yield of grain and forage from the use of manure properly employed. It frequently happens that the greatest profit comes from use of by-products and increase of soil fertility. Careful observation of the cattlemen of any community shows that they are leaders in all public matters, are financially responsible, farm the best land in the community, and are regarded as among the best citizens. Counties and communities noted for their production of beef are noted also for their large yields of agricultural crops and for their great productive wealth.

It is almost impossible, under present methods of rental, to handle beef cattle profitably on a tenant farm. This is due to the fact that the cattle business is one which re-

A group of fine show steers, each a winner of a first prize in the show season of 1913.

quires a considerable number of years to develop and a definite system of farming to produce the feeds necessary for winter maintenance. A further reason is that the chief profit in cattle farming comes from returning the manure to the land, thus increasing the fertility of the soil and the yield of crops. When land is rented annually there is no incentive to build it up to increase production the following year, when a different renter may be farming it.

Kansas as a Beef Cattle State. Kansas is celebrated for the production of beef cattle of superior merit. This is due principally to the large acreage of corn, alfalfa, kafir, sweet sorghum, and milo produced annually, and to the high nutritive quality and the variety of the grasses found in the native pastures of every part of the state. Another factor which makes the state especially fitted for this business is the usual dryness of the feed lots throughout the winter, which enables the cattle to be handled with a minimum amount of shelter, and permits them to use a large proportion of their feed for increase in weight rather than for maintenance.

THE IDEAL BEEF ANIMAL

The ideal beef animal is one which will make rapid and economical increase in weight when given an abundance of feed, which will mature at an early age, and the carcass of which, when slaughtered, will be heavy as compared with the offal. When the carcass is divided into its various parts, there will be found a large proportion of meat which sells at a high price, and a small proportion of the cheaper cuts. There are several points which indicate the value of an animal for beef-making purposes.

The Head. The face should be short and broad between the eyes, which should be large, mild, and placid. The mouth should be large, and the nostrils large and open. The jaws should be heavy and well muscled, enabling the cattle to eat such feeds as ear corn, stalks, and other roughage. The ears should be wide apart at the base and carried in such a way as to indicate a quiet disposition. The head should be in proportion to the body, neither large and coarse nor fine and delicate. These points indicate that the animal has a good constitution and a large capacity for feed.

The Neck. The neck should be short, thick, and heavily muscled. A long, slim neck indicates an absence of heavy, thick muscle throughout the entire body, and is usually associated with inferior feeding capacity or a delicate constitution. A short neck is desirable because the meat from this region is coarse and tough, thus making it one of the cheapest cuts of beef.

The Shoulders. The shoulders and the neck should blend so well as to make it difficult to distinguish where the neck stops and the shoulders begin. The point of the shoulder should not be prominent, but well covered with both flesh and fat. The shoulder should be set well into

the body, thus producing a generally smooth appearance. The tops of the shoulder blades should be lower than the spine, in order that the animal may be rounded out with a minimum amount of fat. A coarse, heavy shoulder is

A beef steer, showing the parts of the animal considered in judging.

1. Muzzle
2. Eyes.
3. Face.
4. Forehead.
5. Ears.
6. Neck.
7. Shoulder vein.
8. Shoulder.
9. Brisket.
10. Jaw.
11. Breast.
12. Dewlap, or heavy skin on neck.
13. Arm.
14. Shin.
15. Leg.
16. Chest.
17. Fore flank.
18. Crops.
19. Ribs.
20. Back.
21. Loin.
22. Hips, or hooks.
23. Hind flank.
24. Purse.
25. Rump.
26. Tail-head.
27. Pin bones.
28. Thigh.
29. Twist.
30. Hock.
31. Shank.
32. Tail.

indicative of coarseness of muscle fiber and of a long and expensive feeding period necessary to finish the animal for the block.

The Chest. The chest should be both wide and deep, with the breastbone, or brisket, well forward, in order to insure ample room for the development of vital organs, such as the heart and the lungs.

The Legs. The legs should be set wide apart, with

short cannon bones and heavy muscling in the forearm. They should be straight, when viewed from either front or side. The bone should be ample to permit the animal to attain maximum size, as well as straight, hard, and clean, indicating strength and quality. The feet should be in proportion to the size of the animal, and should have hard, dense hoof, to permit the grazing of rough and broken land without difficulty. The toes should be close together and should point directly forward.

The Ribs. The ribs should be long, in order to give depth to the body; they should be well sprung, to give capacity for vital and digestive organs; and they should be covered with thick, heavy muscles. The highest-priced meat in the fore quarter is found on the upper part of the last five ribs.

The Back. The back should be wide, straight, and evenly and heavily covered with muscle, indicating superior quality of meat in the carcass. A low back is generally weak, being due to the absence of sufficient muscle to enable the animal to hold it straight. As the price of beef cattle is governed largely by the amount of muscle, or lean meat, and the proper covering of fat, it is important to have as large a development of muscle as possible in the most valuable part of the carcass.

The Loin. The loin is that part of the body immediately in front of the hook bones and behind the last long ribs. When the animal is slaughtered, that portion immediately behind the hook bones is included in the loin. This region demands the highest price of any meat in the carcass. The loin should be wide, thick, and of medium length. The hook bones should be smooth, and their width in proportion to that of the loin and rump.

The Rump. The rump should be wide, long, and level,

without undue prominence of pelvic bones. There should be ample width between the hip joints, and the pin bones should be set well apart.

The Thighs. The thighs are the portion of the hind legs which produces the round steak. This region should be covered with heavy muscles, which should be carried well down toward the hocks. These should be straight and should stand well apart. The twist where the muscles of both hind legs unite should be full and deep.

The Flank. The hind flank should be well let down, so that the underline of the body will be nearly straight, as this indicates capacity for food, and, to some extent, fattening ability.

After studying all the parts of the beef animal separately, it is well to notice that the top line and the underline should be straight and nearly parallel to each other; that the width should be almost the same through the shoulder as through the thighs; that the width just back of the top of the shoulders should be the same as that of the loin, hips, and rump; that there should be an absence of paunchiness and coarseness throughout; that the skin should be smooth, clean, mellow and of reasonable thickness; and that the hair should be bright and clean.

Fat Cattle. In selecting fat cattle, it should be noticed that there is a fullness at the base of the tongue and a thickness in the hind flank. The fat should be evenly and smoothly deposited over the entire surface of the body, with no patches or rolls which must be trimmed from the carcass and sold as tallow.

Breeding Cattle. Bulls for breeding purposes should have strong, masculine heads and heavy crests; they should be thick through the shoulders. Their masculinity should not run to undue coarseness. Cows for

breeding purposes should be refined about the head, with rather long and narrow necks; they should be wide through the hips and pelvic regions; they should have large udders, well-developed milk veins, and large, well-placed teats.

Baldoon, a champion Aberdeen Angus bull.

Breeds. There are four leading breeds of beef cattle: Aberdeen Angus, Galloway, Hereford, and Shorthorn. To these are sometimes added the Polled Durhams and the Red Polls, which have not been so highly specialized for the production of beef. All beef breeds have been bred and fed for the purpose of producing economically animals that will yield a large amount of the best quality of beef in proportion to live weight. There are minor differences in form and specific differences in breed character.

The Aberdeen Angus is black, hornless, and noted for high quality of carcass. It is especially adapted for the production of show steers and for fattening in the corn belt.

The Galloway is also black and hornless; it is noted for hardy constitution, excellent quality of carcass, and the value of the hides for making robes.

A Galloway steer. First prize-winner and champion, 1913.

The Hereford is horned and has a red body, with face, crest, brisket, underline, and brush of tail white. There is more or less white on the legs. The Hereford is noted for hardiness, early maturity, and ability to utilize grass and roughage.

The Shorthorn is horned, and may be red, white, roan, or any combination of these colors. It is noted for size, for quiet disposition, and frequently for ability to produce large quantities of milk. In eastern Kansas the Shorthorn predominates as the farmer's cow where both milk and beef are considered as farm products; the Angus, where beef alone is considered. On the ranges, especially in western Kansas, Hereford cattle predominate, with Galloways second in number.

THE DIVISIONS OF THE BEEF CATTLE INDUSTRY

The production of beef cattle may be separated into four more or less distinct divisions. The four divisions are breeding pure-bred cattle, producing stockers and feeders, grazing cattle, and fattening cattle.

Matchless Dale, a first-prize winner and champion Shorthorn bull.

Pure-bred cattle are sometimes known as registered cattle. They are cattle that have descended from pure strains, and have not been mixed or cross-bred for many generations. They are usually grown for the production of beef and for sale to producers of other kinds of beef cattle. They are used by these men for breeding purposes, to improve their herds. Stockers and feeders are cattle produced by one stockman and sold to another after they are partly grown but before they are fit for slaughter. They are finally purchased by a feeder, who makes it his business to finish them for slaughter. Grazing cattle are

young growing cattle not yet ready to be sold as stockers and feeders, or they may be mature, thin cattle of plain quality, which go to market and are sold as grass-fat cattle. The grazing business depends for its profit upon putting quick, cheap gains on these animals, but usually does not attempt to finish them. Fattening cattle are those which are put on full feed, so that they may be fully fattened and prepared for slaughter.

Producing Pure-bred Cattle. Raising pure-bred cattle is the highest type of beef production, and should be pursued on the richest and most productive farms available. It requires the investment of large amounts of money for a series of years. The best methods of farming, feeding, and management of live stock must be thoroughly understood and put into practice. Buildings and grounds should be kept neat and attractive in order to impress customers with the fact that breeding pure-bred live stock is both profitable and attractive.

Excellent pastures must be available for summer grazing, and the best methods of feeding must be practiced in winter in order that the type and form inherited by the animal may be developed to the maximum. Poor feeding is more frequently the cause of failure on the part of breeders than is any other one factor. In addition to selecting the most approved types of cattle and feeding them successfully, the breeder of pure-bred live stock must be a business man and a salesman, so that he can successfully dispose of that which he has produced. It is usually wise for the beginner to start with grade or market cattle, and after he has met with success, to purchase a few pure-breds, thus getting into the business gradually.

Producing Stockers and Feeders. The production of stockers and feeders should be confined to those localities where the larger part of the land can not be plowed profit-

ably and where grass is the chief crop. They should be produced principally on grass in the summer and on roughage in the winter, with little or no grain. As the western half of the state is peculiarly adapted to the production of grass and roughage, such as kafir and sweet sorghum on the uplands, and of alfalfa in the bottoms, it is logically an area for producing stockers and feeders. Where alfalfa and silage crops can be produced, little or

A scrub bull. Such animals make the production of beef unprofitable even where all other conditions are favorable.

no commercial feed is required. When it is impossible to grow alfalfa, protein should be supplied in the form of cottonseed products, bran, or linseed meal. In this kind of farming the practice of selling calves at weaning time is growing in favor rapidly, especially where the grazing area is limited and shelter is not available. When there is more grass or other feed than can be utilized by the cows, the calves may be held on the farm and marketed as feed ers when either yearlings or two-year-olds.

It is most important that cattle of the best beef type be used in producing either stockers or feeders, as the chief profit comes, as in breeding pure-bred cattle, from producing those of superior merit, for which there is always a keen demand and a high hundredweight value. It is extremely important that the herd of cattle used for this purpose be uniform in type, color, size, breeding, and quality, as buyers of feeders prefer cattle as nearly alike as possible. They should have large feeding capacity and should show promise of developing into ideal fat cattle.

Grazing Cattle. As a general rule, the business of grazing cattle is followed in those parts of the state where the area of land under cultivation is very small as compared with that which must necessarily be kept in grass. The cattle are rarely produced in the grazing regions, but are shipped in by the carload or train load about the first of May and allowed to graze until they are fat enough to find a favorable market as grass-fat cattle. Steers which are three years old or more, and are very thin in the spring, make much larger gains at pasture than younger or fatter cattle. It frequently happens, however, that fleshy cattle can be shipped from grass earlier in the year, thus avoiding extreme heat, annoyance from flies, shortage of water, or an extremely heavy run of cattle on the market, which might more than overcome the larger gains which might be made by longer grazing. Not so much attention is paid to quality or breeding in purchasing grass cattle as in the breeding of pure-bred cattle or stockers and feeders, because the owners are interested in increasing the value of the animals by fattening rather than in the final price to the hundredweight. Therefore the cattle selected to be fattened at pasture are usually older, coarser, and plainer than those which are selected to be fattened in the feed lot.

Fattening Cattle. Fattening cattle has proved profitable in those parts of the state in which corn is the leading crop and in which the area devoted to permanent pasture is relatively small. The age and the class of cattle selected for the feed lot are dependent upon the experience of the feeder, the season of the year, the kinds of feed available, and the probable demand for cattle when fat. Young and thin cattle make cheaper gains in the feed lot than older ones, but as they use a large proportion of their feed for growth they require a longer feeding period to get fat. In fattening calves it is necessary to secure those which have the best possible breeding and quality, being short-legged, blocky, broad, and deep-bodied, otherwise they will use nearly all their feed for growth and therefore will require a long time to fatten. It will require from eight to nine months from the time calves are weaned to make them prime, even on full feeding. An excellent daily ration for each animal consists of ten pounds of silage, five pounds of alfalfa hay, one pound of linseed or cottonseed cake, and all the corn it will eat. Older cattle will eat more roughage in proportion to the grain, and hence are selected for feeding where roughage is available but corn relatively scarce. They will also fatten in less time.

It is necessary to improve the ration as the cattle become fatter, if satisfactory gains are to be secured. In farm practice it is customary to start the cattle on roughage, such as silage and hay and fodder, with about six pounds of corn daily to a thousand pounds of live weight, and to increase the amount of corn as the cattle get fatter, thus making a very short full-feeding period.

In handling show steers it is necessary to improve the ration further by grinding the grain, cutting the hay, adding a greater variety of feeds, and doing everything possible to keep up the appetite of the animals. Sometimes

barley is boiled and fed at the rate of one gallon a day; sugar or molasses is mixed with the grain; fans and window screens are used to keep flies off and to reduce the heat. Every art known to the feeder is utilized when an exceptional animal is to be developed.

King Ellsworth, a pure-bred Aberdeen Angus steer, grand champion of all breeds, International Live Stock Show, 1909.

It rarely happens that cattle are bred, fed, and marketed from the same farm. This fact results in keen business competition between buyers and sellers of breeding cattle, thin cattle and fat cattle requiring a special amount of business ability on the part of the man who is to be successful. If, however, he has the ability to follow the cattle business, a farmer finds it one of the most pleasant and profitable of all lines of farming.

QUESTIONS

1. Describe a beef animal. Why should the body be wide and deep?

2. What place do beef cattle have in the general system of farming in your locality? If cattle have no place, why?

3. Under what conditions is the cattle business more important than crop farming?

4. What breed or breeds of beef cattle are kept in your locality?

5. Under what conditions is it profitable to keep a breeding herd and raise stockers or feeders?

6. Under what conditions are cattle fattened and finished for market?

7. Is it always profitable to finish feeders in the region where they were raised? Why?

8. What would be the advantage of raising your own feeders?

9. Why do not more people handle pure-bred cattle?

10. What method of handling beef cattle is followed in your locality?

11. Give the advantages of this method. Are there any disadvantages?

12. What are the chief roughage feeds produced in your part of the state? What is their value as feed for cattle?

13. How would you fatten two-year-old steers?

14. How does alfalfa rank as feed for calves? Why? How does silage rank as feed for cattle? Why?

15. Why do most cattlemen feed some cottonseed cake, cottonseed meal, or linseed meal?

16. Discuss briefly the value of beef cattle on the farm.

CHAPTER XXIII

HOGS

Hogs are known to have existed in Europe, Asia, and Africa since the very earliest historic times. The hogs of ancient days were wild, ferocious animals, that could run very fast. They had comparatively small bodies and very large heads. The wild hogs grew very slowly, and often lived to be twenty-five or thirty years of age. They usually produced only one litter of pigs a year. The small pigs were not weaned until they were four or five months old, and the mother often protected them from wild animals until they were two or three years of age.

There seem to have been two different types of wild hog from which modern breeds of hogs have descended. One type was found in northern and central Europe and northern Asia. The other type inhabited Africa and the southern part of Asia. These southern wild hogs were smaller, fatter, thinner-skinned, possessed more quality, matured earlier, and were not so wild and ferocious as the northern hogs. It is generally supposed that these two types originated from the same ancestry, and that the differences in them were brought about by environment.

Types of Hogs. Wild hogs were caught and domesticated, especially by the farmers of Great Britain. In modern times, two principal types were derived from these hogs. Some farmers preferred lean hogs from which good bacon could be made, while other farmers preferred fat hogs from which they could secure lard and oil. This

resulted in the development of two distinct types of hog; namely, the thin, or bacon, hog, and the fat, or lard, hog.

The Bacon Hog. The bacon hog has been developed and is raised most extensively in Great Britain, Denmark,

A typical bacon hog. Contrast this hog with the animals in the following picture.

and Canada. In these countries the principal feed for hogs consists of barley, oats, peas, rye, root crops, and wheat. These feeds and the exercise obtained in roaming over pastures tend to produce the best bacon hogs. The most desirable weight of the bacon hog is from 160 to 200 pounds. Very few bacon hogs are raised in Kansas, but in New England, the South, and the far West this type is very common.

The Lard Hog. The lard hog has been developed in that part of the United States where corn is plentiful. This type of hog is noted for its compact, deep, smooth, body, its rapidity of growth, and its ability to fatten. The lard hog, to be of greatest value, should be fattened to a high degree. It is because the lard hog should be

very fat that it can be produced profitably only where corn is plentiful. The most common breeds of hogs in Kansas belong to the fat, or lard, type.

A group of prize-winning Poland Chinas, examples of the lard hog.

Market Types of Hogs. Hogs that are sold on the market for meat are classified, according to their condition, form, and quality, into five principal classes. These classes are prime hogs, butcher hogs, light hogs, packing hogs, and miscellaneous hogs.

Prime Hogs. The prime heavy hog is one weighing from 350 to 500 pounds, and very fat. To belong to this class a hog must have excellent finish and exceptionally high quality.

Butcher Hogs. Butcher hogs are hogs which weigh from 180 to 350 pounds, and are chiefly barrows. It is possible to have a few good sows in a drove of butcher hogs without detracting from the value of the drove. About twenty-five per cent of the hogs that reach the central stock markets belong to this class. Butcher hogs range from six months to a year old. The hogs sold at the age of six months are usually called light butchers, while those sold at the age of one year are known as heavy butchers. The carcasses of these hogs are not cured to ham and bacon, but are sold to butchers and retailed as fresh meat. This is the reason they are called butcher hogs.

Packing Hogs. Packing hogs are so called because they are chiefly used by the packing houses for the purpose of making cured or salt meat. This class of hogs, as a whole, lacks somewhat the quality and finish of the butcher hogs. In this class are fine old brood sows and all other hogs that are heavy enough but not good enough for the butcher hog class, although the very poorest hogs would be ranked, not as packing hogs, but as miscellaneous hogs. About forty per cent of the hogs that reach the central markets are sold as packing hogs. They are nine months old and older. Packing hogs are divided into heavy, medium, and mixed classes, and each of these classes is further subdivided into good, common, and inferior.

Light Hogs. Light hogs include all hogs weighing between 125 and 220 pounds. About fifteen per cent of the hogs that reach the market belong to this class. These hogs are usually from five to eight months old when marketed. The light hogs are divided into bacon hogs, which are used principally for the production of bacon; light mixed hogs, which represent hogs of the light butcher weights; and light light hogs, which weigh from 125 to 250 pounds, and represent the lightest of the class.

Miscellaneous Hogs. Miscellaneous hogs include practically all that are not suitable for the other classes.

Breeds of Hogs. A number of breeds of hogs are raised in the United States to-day. The breeds of the most importance are the Duroc-Jersey, the Poland China, the Berkshire, the Chester White, the Hampshire, the large Yorkshire, and the Tamworth.

The Duroc-Jersey. The Duroc-Jersey is an American breed. It is red in color. Red hogs have existed in the United States for a great many years. From uncertain origin, there was developed in New Jersey a large breed of

red hogs, which became known as the Jersey Red. Another breed of hogs, known as the Duroc, originated in Saratoga county, New York. At a later date the Jersey Reds and the Durocs were brought together, and the two breeds were blended into one under the name of Jersey Red. About 1883 this name was changed to Duroc-Jersey. The improvement of the Duroc-Jersey breed began when the Jersey Red and the Duroc hogs were united. The breed

A champion Duroc-Jersey sow

improved rapidly. It is now known to be very hardy, and is noted for its large litters. It is an early maturing breed which crosses well with other breeds of hogs. The Duroc-Jersey, when crossed with grade hogs or hogs of no particular breed, is especially noted for its ability to improve the offspring..

Mature males of the Duroc-Jersey breed weigh 600 pounds or more, while mature females weigh 500 pounds

or more. The snout of the Duroc-Jersey is of medium length. The face is slightly dished or straight. The ear droops about two-thirds of its length. The body is noted for its thickness and depth. The color of a Duroc-Jersey varies from light yellow to dark red, but cherry color is the most desirable. A few black spots on the under parts and legs do not disqualify a hog, but are objectionable markings.

The Poland China. The Poland China hog is strictly of American origin. The breed originated in the Miami valley of Ohio. The foundation of this breed was probably the common stock of the country, which was more or less mixed in breeding. In the early days these hogs were given various names, as Butler County, Warren County, Miami Valley, Poland, and China. The name Poland China was officially adopted in 1872. The Poland China has been developed especially to meet the market demand for a lard hog. Hogs of this breed have been bred for early maturity for generations, and are noted for ability to produce a finished fat carcass at an early age. The Poland China is valuable for crossing with hogs that lack the tendency to fatten easily.

The face of the Poland China hog is practically straight and the jowl full and heavy. The ears are fine, with the tip drooped. The color of the hog is black, with white on the face, the feet, and the tip of the tail.

The Berkshire. The Berkshire is one of the oldest breeds of improved swine. Its original home was in Berkshire and Wiltshire, in southern England. This breed of hogs has been distributed all over the world. It was first introduced into the United States in 1823. Certain types of the Berkshire are exceptionally good bacon hogs, but in this country, especially through the part of the United

States where corn is plentiful, Berkshires are classed as lard hogs. The breed is noted for its hardiness, vitality, and ability to fatten evenly and smoothly.

The Berkshires are symmetrical in form and stylish

A group of pure-bred Berkshire gilts. This group of gilts brought a higher average price at sale than any other gilts sold in the West the same year.

in carriage. The face is dished, the snout and the neck are short, and the ears are erect. A hog of this breed is black with white markings on the face. There are also white markings on each foot and on the tip of the tail.

The Chester White. The Chester White originated in Chester county, Pennsylvania. Hogs of this breed are very large, and compare favorably with hogs of other breeds in ability to mature early and to produce meat economically. The Chester White does well upon pasture, but, on account of the white skin, often has skin trouble when exposed to unfavorable weather.

The face of the Chester White is slightly dished, and the snout is usually a little longer than the snout of the Poland China. The color is white throughout, and any black disqualifies the animal for this breed. The hair is sometimes wavy and curly.

The Hampshire. The Hampshire hog originated in Hampshire, England, and was brought to Massachusetts

about 1895. At that time the breed was known as the thin-rind, but in 1904 the name was changed to the Hampshire. The Hampshire is a very active, hardy breed, and

A Hampshire sow.

is especially noted for large litters of pigs. This breed was originally a bacon type, but has been gradually changed to the lard type since coming to this country.

The face of the Hampshire is straight, with ears which are inclined forward and outward, but which do not droop like those of the Poland China. The back is strong, the ribs are well sprung, and the sides are deep. The color is black except for a white belt which encircles the body.

The Large Yorkshire. The Large Yorkshire is of English origin. It descended from a race of large, coarse-boned, white hogs common in Yorkshire, England. This breed of hogs belongs to the bacon type, and is valued for the

amount and the quality of bacon produced by it. Because of the tendency of the skin to get "scalded" by the sun, the Large Yorkshire seems ill adapted to localities which have an especially hot climate.

The face of the Large Yorkshire is moderately dished, with snout straight and of medium length. The ears are large and erect, but are sometimes inclined forward. The color is white.

The Tamworth. The Tamworth originated in central England. This breed belongs to the bacon type of hogs, and it has often been asserted that the Tamworth produces a better quality of bacon than any other breed of hogs. The Tamworth is a very large, rather long hog. The snout is straight, and there is scarcely any dish to the face. The ears are large and are carried erect. The Tamworth should have golden red hair, free from all black color. The hair sometimes changes to a chestnut color as the hog grows older.

FEEDING HOGS

Hogs require as good care and careful feeding as any class of live stock. The successful feeder must know the value of different feeds and the method of combining these feeds properly to secure best results. Many farmers waste large amounts of feed every year by improper and careless feeding.

One of the first considerations in hog feeding is not to overfeed. It is better that the hog be a little underfed than overfed. Fresh feed should not be thrown into the hog trough if the trough contains any old or sour feed left from previous feedings. The hog should be fed at frequent and regular intervals. Drinking water should be provided so that the hog has access to it at all times.

Kinds of Feed. Corn is one of the richest and most

palatable feeds for hogs, and, because of the ease with which it can be grown and the high yield obtained in this part of the country, it has become the principal grain used in feeding hogs. Because corn is usually a cheap food for hogs, it should be fed in as large quantities as possible; but it should be remembered that corn is deficient in certain nutrients, such as protein and calcium, and that, when fed this grain alone, the hog does not develop the bone and muscle that it should. It is therefore best to feed with corn other materials, such as tankage, meat meal, wheat middlings, oil meal, skim milk, and alfalfa, that will furnish the constituents in which corn is deficient. Brood sows or young pigs, running in pasture, will thrive better if fed alfalfa hay than if given corn only.

Sanitation. Cleanliness is especially important in raising hogs, and they will benefit from clean, well-drained, well-aired quarters as much as any other kind of domestic animal. Their quarters should be cleaned regularly, and no stagnant mudholes should be allowed to form. In winter the hogs should be protected and should not be exposed to drafts; but, on the other hand, they should not be kept too warm. Drafts or a sudden change from a close, hot shed to the cold outer air frequently causes influenza.

Cholera and other contagious or infectious diseases are spread by running water to which diseased hogs have access, or by dogs that eat parts of diseased carcasses and carry disease to other farms. Every farmer should burn or bury deep all hogs which die, regardless of the cause. If he fails to obey the law in this respect, he should be prosecuted. When any hog disease is prevalent in a community, no hogs should be allowed to run at large, no dogs or stock should be allowed to go from farm to farm

if they can get to the hog pens, nor should men under any circumstances visit a yard containing a sick hog and then go to another farm without careful disinfection of their shoes. Lime or mixtures of carbolic acid and water used about the pens and sheds lessen the danger of disease. Deep plowing of the lots is also a good practice.

JUDGING THE LARD HOG

General Appearance. In judging a hog, weight, form, quality, and covering should be considered under general appearance. The hog that weighs from two hundred to three hundred pounds brings the highest price on the market. The standard weight for any given age comprises an average daily gain of one pound from birth.

The general form of the lard hog should be compact, with the body deep, broad, smooth, and symmetrical. The hog should have the larger part of its weight in the region of the valuable cuts; that is, along the back, loin, and hams. Its underline should be straight. It should have smooth shoulders, wide, thick back, and deep, full hams and sides.

Quality. Quality is denoted by fine hair, free from bristles; smooth, clean skin; clean bones; and a general smoothness of conformation. The skin should be free from wrinkles.

Condition. There should be a deep, even covering of flesh, especially in the regions of the valuable cuts. The finish should be even, mellow to the touch, and free from wrinkles and lumps. A hog that is wrinkled and lumpy yields a carcass that is rough and uneven. Condition determines the selling value of the hog. Condition is indicated by the general plumpness of form, the depth of covering over back and loin, the amount of fat at the

root of the tail, and the fullness and thickness of the sides and jowl.

The Parts of the Hog. The snout (1) should be medium in length and not coarse. The eyes (2) should be

A Poland China sow, marked to show the parts of the hog.

mild, bright, and not sunken or obscured by wrinkles and fat. The face (3) should be short, with the cheeks full. The ears (4) should be fine, of medium size, and attached neatly. The jowl (5) should be full, firm, neat, and free from flabbiness.

The neck (6) should be short and should possess sufficient width and depth to swell smoothly into the shoulder vein and pass back without any noticeable depression. The shoulders (7) should be long, full, and level on top. They should not be too heavy or coarse, as they constitute a comparatively cheap cut. Coarseness here, moreover, indicates coarseness of fiber. The breast (8) should be full, smooth, and neat.

The fore legs (9) should be straight, short, and strong, and placed wide apart. The pasterns should be strong, and

not broken down so that the animal walks on its dewclaws; the feet should be of medium size.

The chest (10) should be deep and wide, with a large heart girth, as this insures constitutional vigor and vitality.

The sides (11) should be deep, thick, and as long as possible consistent with strength of back. The ribs should be well arched and should continue low down, giving great feeding capacity. The underline should run straight from front flank to rear flank, giving the side an even width. The sides should be free from wrinkles and creases, as these indicate uneven flesh, poor in quality.

The back (12) should be broad, strongly arched, and thickly and evenly covered with flesh. "Fish back," low back, and lowness just back of the shoulders are very objectionable.

The loin (13) should be broad, strong, full, and thickly fleshed. The width of the loin should be such as to sustain the width of the back.

The under part (14) should be straight, smooth, and firm, with width in proportion to the size of the hog.

The hips (15) should be wide apart and smooth. They should be as wide as the body, and smoothly covered with flesh. The rump (16) should be long, level, wide, and evenly fleshed. Narrow, peaked rumps mean thin hams, which do not sell well on the market. The width should be carried back proportionately to the back. The hams (17) should be heavily fleshed, full, firm, deep, and wide, and should be carried well down to the hocks. Firmness indicates high quality of meat.

The hind legs should be straight, short, strong, with bone clean and hard; pasterns short, strong, and upright; feet of medium size. The most common defect of the hind leg is a cramped condition of the hock. The hog's

legs should be well set so that he does not walk with an awkward gait.

JUDGING BREEDING HOGS

The brood sow that regularly produces large, strong, uniform litters of pigs is the most valuable. All breeds of lard hogs are more or less similar. Breed differences are due more to variations in color, set of ear, and dish of face.

In judging brood sows, the size is very important. In form the sow will be longer. She should have a deep, broad and roomy body, with strong constitution and great vitality. Other important points in choosing the brood sow are the feet and legs, quality, disposition, and femininity as indicated by refinement about the head and face.

MEAT ON THE FARM

The farmer, of all persons, should have a good supply of the best kind of meats for his own table. He should be independent of the butcher; that is, he should slaughter his own animals and cure his own meats. Butchering may be done when work is slack, and means a very great saving to the farmer. It should be a part of the regular work on each farm.

Slaughtering. The animal to be slaughtered should be young and fat, gaining in flesh and healthy. The animal should not be fed for at least twenty-four hours before being slaughtered. It should be given plenty of water to drink and should be kept quiet, in order that its temperature may not rise above normal. An increase of two or more degrees will result in a gluey, sticky meat which will not keep well. The animal should never be struck with any object that will bruise the flesh, as bruising tends to form a blood clot and the bruised portion will have to be discarded. The animal should be stuck in such a manner that its system will be thoroughly drained of blood.

Meat properly trimmed.

Scalding. Where only a few hogs are slaughtered a barrel makes a very good vessel in which to scald them. If the hog is a large one it may be covered with blankets or sacks and the water poured over these blankets. The water should be heated to between 170 and 180 degrees Fahrenheit. Some wood ashes, lye, or soda should be put into the water to loosen the dirt and scurf.

Cutting. Never cut a carcass of any kind until it has been thoroughly cooled throughout. Lay the hog on a block or a table and remove the head at the atlas joint, or about two inches behind the ears. Remove the shoulder between the fourth and fifth ribs. Cut out the fore ribs and finish trimming the shoulder. Cut the hams off about two inches in front of the pelvic arch, and split the carcass in the middle of the backbone. Trim the meat. The middle piece should be split down the middle, the ribs and loin taken out, and the sides cut into strips for bacon.

Curing. Meat should be thoroughly cooled before being cured. If the animal heat is not all out of the carcass it will not take the cure evenly and may spoil afterwards. The meat to be cured should be placed in good, clean vessels in a cool place, where the temperature is even.

There are two methods of curing meat in common use, both of which are good. These are the dry cure and the brine cure. The farmer should choose the one he likes best, though it is true that the highest quality and the richest flavor will be produced through the use of the dry cure. Brine destroys some of the soluble protein in the meat, and thus removes some of the flavor and food value. Any piece of meat which has been soaked, or even wet, is never again so good as it was.

Dry Curing. Two of the commoner methods of dry curing are given here.

For one thousand pounds of meat, use the following compound: forty pounds of common salt; ten pounds of New Orleans sugar; four pounds of ground black pepper; one and one-half pounds of saltpeter; one-half pound of Cayenne pepper. Weigh the meat and use a proportionate part of the compound. After the ingredients have been properly mixed, use half of the amount for rubbing into the meat. Place the meat in a dry, cool place. Allow it to remain for two weeks, then rub on the remainder of the cure and let the meat lie for six weeks, when it is ready to be smoked.

A slightly simpler dry cure employs to each one hundred pounds of meat five pounds of salt, two pounds of brown sugar, and two ounces of saltpeter. Mix the ingredients thoroughly, and rub each piece of meat once a day with one-third of the mixture. Do this on three successive days. Keep the meat in a cool, damp place.

Liquid, or Brine, Cures. For a sugar cure, rub each piece of meat with salt and allow it to drain over night, then pack it closely in a barrel, with the hams and the shoulders at the bottom and the strips of bacon on top. To each one hundred pounds of meat use eight pounds of salt, two pounds of brown sugar, and two ounces of saltpeter. Dissolve these ingredients in four gallons of water, and cover the meat with the brine. It is best to boil the brine and let it cool before using it. The bacon strips should remain in the brine from four to six weeks; the hams and the shoulders, from six to eight weeks.

Plain Salt Pork. To obtain plain salt pork, rub each piece of meat with common salt, pack the pieces closely in a barrel, and let them stand over night. To one hundred pounds of meat use ten pounds of salt and two ounces of saltpeter dissolved in four gallons of boiling water. When

the brine is cold pour it over the meat and weight the meat down. The meat should be kept in the brine until it is used.

Sugar-cured hams and bacon are the most satisfactory under ordinary farm conditions, and, when properly cured and smoked, will keep through a hot summer.

Smoking Meats. Where a large amount of meat is to be smoked a good house should be built. The essentials in building a smokehouse are that it be high enough to keep the meat a good distance from the fire, and that it be well ventilated, and should be dark, so as to keep out insects.

Hard woods, such as hickory, maple, oak, and apple are the best fuels to use in smoking meats. Soft, resinous wood imparts a bad flavor to the meat. Clean corncobs make a very good fuel where hard wood can not be obtained. The meat should be smoked with a smouldering fire and with as little heat as possible.

Smoking should be done slowly, and should occupy from three to six weeks, with very little heat. Slow smoking gives a very delicate flavor. After smoking is finished, wrap each piece of meat in paper, put it into an unwashed flour sack, and hang it in a dry place.

Keeping Smoked Meats. Smoked meats may be kept in the smokehouse; or a dry, cool cellar with free circulation will be a satisfactory place for smoked meats at all seasons if it is kept dark.

If the meat is to be kept for some time, the pieces should be wrapped separately in paper and put in unwashed flour sacks or paper sacks, or covered with canvas, or buried in a grain bin, in order to insure a uniform temperature and to keep away insects. A coat of ground pepper rubbed into the meat before it is wrapped will increase the keeping qualities and will not be disagreeable to the taste.

Hams cured in this manner may be kept under ordinary farm conditions throughout the summer, and indeed for several years. The shoulders and bacons should be eaten early in the season; the hams should be kept for harvest and fall. It is a good plan to keep one or two choice hams for the Christmas season.

Pork Sausage. Pork sausage should be made only from clean, fresh pork. To each three pounds of lean pork add one pound of fat; in grinding the meat, mix the fat and the lean together. After the meat is run through the grinder spread it out thinly, and season it to the taste. One ounce of fine salt to each four pounds of meat produces satisfactory results. Black pepper and sage may be added to suit the taste.

QUESTIONS

1. Describe the lard type of hog; the bacon type. How do they differ from each other?
2. Name the market classes of hogs. How do these classes differ? Look up in a daily paper the prices paid for the various market classes of hogs, and discuss the matter in class.
3. What breeds of hogs are raised in your part of the state?
4. Why is the Duroc-Jersey popular? the Poland China? the Berkshire?
5. Why is corn a good hog feed? Why should hogs have some feed besides corn?
6. How and why may alfalfa be used as a feed for hogs?
7. Why do we feed tankage and shorts to pigs?
8. Why is protein essential in the ration of growing pigs? of fattening pigs?
9. How is hog cholera spread? What method of prevention may be used if a farmer does not have cholera in his herd?
10. Why should the farmer do his own butchering?
11. What kind of animal should be slaughtered?
12. Discuss briefly a dry cure; a brine cure.
13. When should meat be smoked? How should you smoke meat? Discuss.
14. How should smoked meat be stored?

CHAPTER XXIV

SHEEP

The sheep was one of the first animals to be domesticated by man. Its value as a producer of both food and clothing was recognized by man in the first stages of civilization. Its flesh was used for food and its skin for clothing by man as long ago as we can trace his history. As man advanced in civilization the wool was cut from the sheep's skin and woven into cloth.

Sheep are well adapted to rough hillside pastures where feed is not abundant enough for cattle or horses. Their habit of moving about while feeding enables them to find widely scattered bunches of grass and young shoots of trees and shrubs, of which they are very fond. In countries

Sheep need shade.

where sheep are kept in large numbers they are driven from one pasture to another and allowed to feed as they go. They are cared for by a shepherd, who usually has one or more dogs to assist. In winter, when feed is scarce and the weather is cold, the shepherd must work hard to

care for his flock. In England, where the farms are small and many sheep are raised, they are kept in small flocks and pastured on rape and clover during the summer and fed on cabbage and turnips during the winter. The sheep which are found on the farms in the United States have nearly all descended from those originated in England. Those found on the large ranges in the Rocky Mountain region have descended from sheep originated in Spain and France. Those kept on the farms are raised for both wool

Representatives of (1) medium-wooled, (2) long-wooled, and (3) fine-wooled breeds.

and mutton, while those on the ranges are kept chiefly for the production of wool. The English breeds of sheep are not adapted to the range, because their fleece is not dense and oily enough to keep out snow and water, and they have been kept in small flocks for so many generations that they have lost the instinct of flocking together when feeding, and hence are very difficult to herd. The sheep from France and Spain have a dense, oily fleece which protects them, and they have been raised in large flocks so long that several thousand of them will flock together.

These two characteristics make them especially adapted to living on the range.

The Breeds of Sheep. All sheep may be divided into three classes, according to their wool: the fine-wooled breeds, the medium-wooled breeds, and the long-wooled breeds.

Fine-wooled Breeds. The fine-wooled breeds are kept chiefly for the production of wool. The skin of a sheep of this class has folds or wrinkles, which give more surface for wool to grow on; and its body is rough and angular. The breeds which are classed as fine-wooled are the American merino, and the Rambouillet, or French merino. The American merino has descended from sheep which were imported from Spain in the early part of the nineteenth century. It is called the American merino because it has been improved so much since the first sheep were imported that it is almost entirely different. The breed is divided into three classes. Members of class 1 have folds of loose skin all over the body, and their wool is denser and finer, and contains more yolk, or oil, than that of the others. Members of class 2 have fewer folds and a longer, less dense wool. Members of class 3 have very few folds, and these only on the neck, and are smoother-bodied, producing less wool and more mutton than the other classes. The French merino, or Rambouillet, sheep are larger than the American merinos. They were imported to this country from France, and have become very popular in the western states, where sheep are raised on the ranges. They produce a large quantity of fine wool and are fair producers of mutton. The rams of all the merino breeds have horns; the ewes are hornless.

Medium-wooled Breeds. The leading breeds of the medium-wooled class are the Shropshire, the Hampshire, the Oxford, the Southdown, the Dorset, and the Cheviot.

The first four of these breeds are often called Downs breeds, because they originated in the Downs, the chalk uplands of southern England. Each breed is named for the part of the country where it was developed.

The Shropshire has dark brown face and legs, and its face is covered with wool well down to the nose. The ears are small and erect, and the head is set high, giving the animal a pleasing appearance. The body is broad, and is set on short, strong legs. The Shropshire ranks high as a mutton producer, and the wool is of good quality. A Shropshire ram weighs 225 pounds, and a ewe 160 pounds. Neither the rams nor the ewes have horns.

The Hampshire may be distinguished from the other Downs breeds by its black face and legs, and by its large ears, which stand nearly straight out from the head. The Hampshire is a good producer of both wool and mutton. The lambs grow rapidly and are usually heavier than Shropshire lambs of the same age. The wool is not of so good quality as that of the Shropshire.

The Oxford is the largest of the Downs breeds. The face and legs are dark brown in color and are not so well covered with wool as are those of the Shropshire.

The Southdown is the smallest of the Downs breeds, and the best for mutton. The face and the legs are brown or mouse-colored, and are not well covered with wool. The ears are small, and the head is carried erect, giving the sheep a very attractive appearance.

The face and the legs of the Dorset are white. Both rams and ewes have horns. Dorset sheep are very prolific, and often produce lambs twice a year. The ewes are heavy milkers, and the lambs grow very rapidly.

The Cheviot is a small breed, with slightly longer and less dense fleece than the other medium-wooled breeds. The head is almost free from wool and is white. The ears

are carried erect, causing the sheep to look alert. The Cheviot is very hardy and does best on rough, high land.

Long-wooled Breeds. The long-wooled breeds are the Leicester, the Cotswold, and the Lincoln. They are larger

The champion grade wether at the International Live Stock Show, 1912.

than any of the medium-wooled breeds except the Oxford, and the wool is longer but less dense. They are often called the lowland breeds, because they were developed in the low parts of England, where feed is plentiful.

The Leicesters are divided into two distinct breeds: the Border Leicester, which has a bare head; the English Leicester, which more closely resembles the Lincoln and has some wool on the forehead. The wool of the Leicester is lighter and less dense than that of the Lincoln or the Cotswold, and has a peculiar curliness

The legs are more slender and the body is smaller than in the other long-wooled breeds.

The Cotswold has a longer neck than the Lincoln or the Leicester, and a long forelock of wool hangs down over the forehead. The wool is long and wavy.

The Lincoln is the largest of the English breeds. The wool of the Lincoln is longer and less wavy than that of other sheep of its class. The fibers mass together and fall away in heavy flakes.

Handling Sheep. Sheep are very timid and should not be frightened by loud noises, strange dogs, or any other unusual disturbance. Their flesh is easily bruised, and a bruise may be followed by serious trouble. In catching a sheep, one should grasp it by the lower jaw or by the front of the hind leg just at the flank. Any pull on the fleece or the skin loosens the skin, ruptures many tiny blood vessels, and causes great pain. The fleece should never be carelessly opened, nor should holes be made in it, since the quality of the fleece is thus injured. The first thing to learn in handling a sheep is to keep the fingers of the hand close together and not to stick the fingers into the wool.

Judging Sheep. The heavy covering of wool makes it difficult to get an accurate idea of the shape of the sheep's body and the development of the parts from which the butcher gets the most valuable cuts of mutton. In judging fat sheep or sheep which are to be butchered, the most important points are condition, form, and quality. Condition covers the amount of fat or flesh. The back, the loin, and the rump should be well covered, and the thigh, known as the leg of mutton, should be full and round. The form of the sheep's body should be rectangular, and equal in width at hips and shoulders. The back should be well carried and the ribs well sprung. Quality includes both

general quality and quality of flesh. General quality is shown by fineness of bone, thinness of ears, and fine silky hair on the nose and on the legs below the knees and the hocks. General quality indicates the fineness of the fibers in the meat. In addition, should be determined the question of evenness of flesh; that is, whether the fat which covers the body is distributed equally over the back and the loin.

The Parts of a Sheep.

1. Muzzle.	6. Top of shoulder.	11. Back.	16. Belly.
2. Face.	7. Shoulder.	12. Loin.	17. Flank.
3. Eye.	8. Chest.	13. Hip.	18. Rump.
4. Ear.	9. Brisket.	14. Ribs, or side.	19. Thigh.
5. Neck.	10. Fore leg.	15. Fore flank.	20. Hind leg.

In judging a sheep, first get far away from the animal and observe the form, taking side, front and rear views. Note the style, which is indicated by the carriage of the head. Now approach the sheep and begin to determine the extent to which the wool has deceived the eye. With a hand on each side of the neck, press firmly down to deter-

mine the fullness of the neck. Working back over the shoulders, feel for compactness on top and covering on the sides. With one hand press firmly down on the back to examine it for covering of flesh and for weakness. With one hand on top and the other below, note depth of chest, and with a hand on either side, width of chest. Feel carefully over the loin for covering of flesh. With the hands flat against the sides, determine the width of the loin. Examine the rump for length and covering of flesh, and try to span the leg at the thigh with both hands to determine the size of the leg of mutton. When the form of the sheep has been determined with eye and hand, open the wool on the side, back of the shoulder, and note the color of the skin, the evenness of crimp or waviness of the fibers, and the amount of yolk or oil in the fleece. The skin should be a bright pink. The crimp of the fibers should be even, and the yolk well distributed.

In judging breeding sheep the same process is carried out, but more attention is paid to breed and sex characteristics than when judging fat sheep. Breed characteristics are those characteristics, such as color of face and kind of wool, which distinguish the breed to which the sheep belongs from other breeds.

As sex characteristics, the ram should have the heavy head, the short, thick neck, and the aggressive expression which denote the male sex in sheep. The head of the ewe should have a more delicate appearance, and her neck should be more slender than that of the ram.

Feeding Sheep. Sheep respond very quickly to good feed and care. They require feeds higher in protein than do other animals. Alfalfa, clover, and pea hay make the best roughage. The grain ration should consist of corn with bran and linseed meal or oats. Sheep make good use of weed-infested pastures, as they will eat eighty per cent

of the common weeds, while cattle or horses will eat only fifty per cent. They do well on wheat pastures in winter. Lambs may be allowed to run in standing corn and will not damage the corn, but old sheep soon begin to tear down the stalks and eat the ears.

Sheep increase rapidly, and the double income from lambs and wool makes it possible for the man who keeps a carefully selected flock and takes good care of it to double each year the money which he has invested.

QUESTIONS

1. To what kind of pasture are sheep best adapted?
2. Compare the methods of handling sheep in England with those employed in France and Spain.
3. What are the requirements for a good range sheep?
4. How may sheep be classified according to wool?
5. Give the classes of American merinos and tell how they may be distinguished from each other.
6. Name the leading breeds of medium-wooled sheep and give the distinguishing characteristics of each breed.
7. Why is the word "Downs" often applied to the Shropshire, Hampshire, and Oxford breeds?
8. Name and give the distinguishing characteristics of the long-wooled breeds.
9. What cautions should be observed in handling sheep?
10. In judging fat sheep, what are the most important points to be considered?
11. Name and locate the five most important cuts of mutton.
12. What is meant by crimp? by yolk?
13. What are breed characteristics? sex characteristics?
14. What feeds are best suited to sheep?
15. For what are sheep useful on the average farm?

CHAPTER XXV

DAIRYING

As meat becomes more costly, there is a greater demand for dairy products, such as milk, butter, and cheese. These are among the very best of human foods if they are produced under clean, wholesome conditions.

The farmer who expects to produce milk, cream, butter, and cheese profitably should keep cows bred and selected for their ability to produce large amounts of rich milk. It does not pay to feed and milk scrub cows. By keeping good cows of the milk type and being careful and cleanly, the farmer may convert the rough feeds and grains of his farm into relatively high-priced and desirable food for mankind.

Increasing Milk Production. A very large proportion of the cows kept for milking do not yield a profit to the farmer; that is, they are just ordinary cows, and have not been well selected. The average cow kept for dairy purposes in the United States produces in a year about 140 pounds of butter. About one-third of the cows in Kansas are kept for dairy purposes, and they produce an average of only 120 pounds of butter each year. Such cows do not pay for their feed and care, much less yield a profit. There are in the United States a number of dairy herds the members of which average three hundred or more pounds of butter a year.

There were in 1913 about 863,000 cows in Kansas, and

in that year they produced nearly $14,000,000 worth of butter. That is only a little over $16 a year for each cow—not enough to pay for feed and care. If the farmer is to profit from his dairy work, he must dispose of his poor cows and use only those which produce large amounts of rich milk and remain in milk for long periods.

Selection of Dairy Cows. There are two ways of selecting dairy cows: first, according to the shape, or type, of the animal; second, according to the milk or butter she produces.

Selection according to type, or form, is the method usually adopted, and in most cases is the only feasible method, because it is difficult to buy cows with good records. Choosing cows by their records of production is much more accurate than choosing them by their shape, but it is true that all high-producing dairy cows are very much alike in form and are of what is known as the dairy type.

The Dairy Type. When the cow roamed wild she gave but little milk, and gave it for only a few months during the year. The larger amount of milk now given by a dairy cow is due chiefly to the process of selection, and the selection, if carried on, will continue to increase the amount.

It will be worth while for the pupil to look at a beef cow and a dairy cow together. He will find that a dairy cow differs from a beef cow in that she is thin and angular, while the beef cow is thick and blocky in form. The head of the dairy cow is neat and delicate; the neck is long and slender and not fleshy; the withers are sharp, and there is absence of heavy muscles along the back; the chest is wide and deep, showing plenty of room for heart and lungs; the stomach, or barrel, is large, provid-

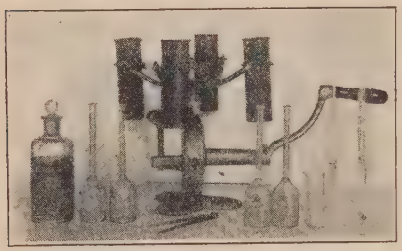
ing plenty of room for storing feed; the loin is wide and strong; the hips are wide apart, and this width is carried back, making a long, wide rump; the udder is attached high behind and far forward on the barrel; the hair on the udder is fine and soft; the milk veins that run from the udder forward are large and enter into large openings, or milk wells. The fact that the cow is lean in appearance indicates that she is inclined to make milk rather than to put fat on her body. The large barrel indicates feeding capacity. A large udder indicates ability to produce large amounts of milk, and the size of the milk veins indicates somewhat the amount of blood that goes to the udder, where the milk is made. Besides these points, a cow should have soft skin and hair, which indicate a good digestion.

It is worth while for the pupil to study this carefully, and apply it by looking at as many different cattle as he can, for a trained eye for good cows is very valuable in buying a herd.

Keeping Records of Dairy Cows. While it is not difficult to distinguish between a poor cow and a good one by appearance, it is not always possible to tell the difference between a fair animal and a good one. Consequently the reliable method to use in judging the ability of an animal to produce milk is to keep records of the productions of each cow in the herd.

If the milk is sold from the farm, the milk from each cow should be weighed and the weight recorded. A cow that does not produce four thousand pounds of milk, or 465 gallons, a year is not worth her keep, and should be sold for beef. If butter fat is sold, it is necessary to know the amount of butter fat produced by each cow. The milk should be weighed, and at least once a month a

sample should be taken and tested with the Babcock tester. (See directions in the Appendix.) Suppose the sample taken at the morning and night milkings for one day is found to test 4.2 per cent. This means that in every hundred pounds of milk there are 4.2 pounds of butter fat. Consequently, if the cow gives 650 pounds of milk in a month the amount of butter fat for the month is 27.3 pounds. By keeping only the best cows and by using pure-bred sires of merit one may soon bring the production of the herd up to a high standard.



Babcock testing outfit. This outfit is large enough for testing the milk of a herd of ten to fifteen cows.

The Dairy Breeds. Where one has a market for milk and cream and desires to keep a small herd of cows it is better to use cattle of a dairy breed than to use beef-bred animals.

The dairy breeds have been selected in the same way in which the individual can select his animals for the purpose of large production. It is as difficult to get profitable production of butter and milk from the beef animal as it would be to win a race with a draft horse.

The four principal breeds in order of quantity of milk produced are the following:

1. Holstein.
2. Ayrshire.
3. Guernsey.
4. Jersey.

Their rank in the richness of milk, naturally enough, is just the opposite:

1. Jersey.

2. Guernsey.
3. Ayrshire.
4. Holstein.

There are also other dairy breeds, such as the Brown Swiss, the Dutch Belted, and the Milking Shorthorn.

The Jerseys and the Guernseys are named for the islands in which they were developed. Both of the islands are in the Channel Island group, Jersey being the largest island and Guernsey the next.

Jerseys. The Jersey is the smallest of the dairy breeds. In color the animals range from a light yellow fawn to a very dark fawn and may have white spots. The nose, the tongue, and the switch of the tail are usually black,

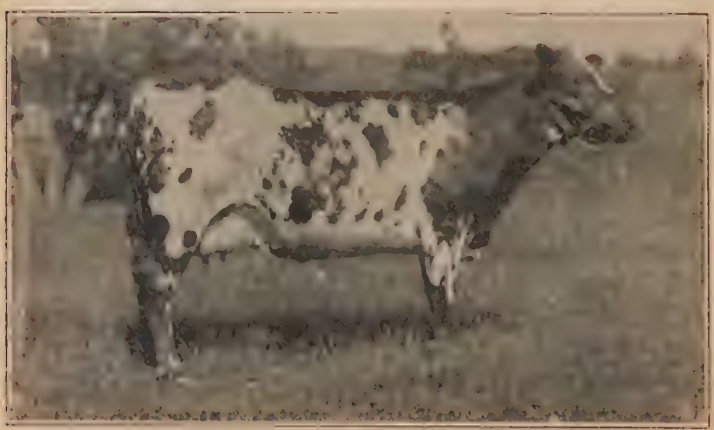
Owl's Design, a pure-bred Jersey, holds the record of Jerseys in Kansas. She produced 14,606 pounds of milk and 765 pounds of butter in one year.

although there are some animals which have white markings in these places. The milk of the Jersey cow contains about five per cent of butter fat.

Guernseys. The Guernsey breed is somewhat related

to the Jersey, but differs in that cattle belonging to it are a little larger and have slightly different colors. Guernseys are fawn color, with either a lemon or an orange

Bernare Countess 2d, a pure-bred Guernsey. Her record for one year as a two-year-old is 9914 pounds of milk and 610 pounds of butter.



Elizabeth of Juneau, a pure-bred Ayrshire, holds the world's record for a three-year-old of this breed. She produced 15,122 pounds of milk and 626 pounds of butter in one year.

tint, and have white spots on their bodies. Nose, tongue, and switch, which in the Jersey are ordinarily black, are usually white in the Guernsey. Guernseys are noted for the rich color of their milk, which contains about 4.8 per cent of butter fat.

Ayrshires. The Ayrshire cow originated in Scotland, not far, therefore, from the place of origin of the two breeds just mentioned. Cows of this breed are spotted red and white, and larger than Jerseys or Guernseys. While they give a larger quantity of milk, it is not so rich in butter fat, containing only from 3.8 to 4 per cent.

Maid Henry, a pure-bred Holstein cow, holds the highest record in the state of Kansas. She produced 19,6 0 pounds of milk and 835 pounds of butter in one year at the age of thirteen years.

Holsteins. The Holstein cow is the only one of the four chief dairy breeds that was developed on the continent of Europe. It is, however, the oldest dairy breed; for cattle were probably first brought to the islands off the coast of Europe from the continent itself. The Holstein comes from Holland, having been bred in the Low Countries for

two thousand years, or since a hundred years before the Christian era. It is the largest breed of dairy cattle. In color it is black and white. Holstein cows give exceedingly large quantities of milk, which contains, however, as a rule, only about 3.5 per cent of butter fat.

Feeding the Cow. During the summer the cow depends largely upon grass for food; but if a cow is giving a large amount of milk she should be fed some grain while on pasture, especially if the pasture is short. In winter cows

Interior view of the dairy barn at the Kansas State Agricultural College, equipped to handle seventy milk cows.

must be given plenty of feed so that they will furnish all the milk they are capable of giving. If the cows obtain some green, juicy feed in the winter, such as silage, they will do much better than if they are forced to eat dry feed entirely. On the majority of farms all the cows in a herd are fed alike. They get the same amount of hay and the same amount of grain, and receive the same attention. This is a poor practice, because the cows that give a large amount of milk need more feed than those that give only a small amount.

The cow should at all times have clean water. In winter she should have freshly pumped well water, for if she has to drink ice-cold water she will fall off in her production of milk, and will usually prove unprofitable.

Stabling. In order than an animal may do its best in either growth or production it must be not only well fed and watered, but kept in a clean, warm, and well-lighted place. The dairy cow, since she does not put much fat on her body to keep her warm, must be kept in the barn during cold weather. This barn should be warm, and should have plenty of fresh air and plenty of sunlight. If the stable is dark and dirty the cows will not produce so well, and the milk they do produce will not be fit for any one to drink. If the cow is given a chance to keep clean, she, like most other animals, will do so. It is only by keeping her and her surroundings clean that clean milk can be produced.

Milking. The milking should be done as quickly and as quietly as possible. All the milk must be taken from the cow each time, for if there is any left in the udder the cow will soon go dry. If the cow is dirty, she must be cleansed, because it is necessary to have everything clean if clean milk is desired. The milker's hands and the cow's sides and udder should be cleansed before the milking is begun. One can obtain cleaner milk by using a milk pail that is partly closed at the top, as shown in the picture.

Two types of milk pail. The partly covered pail keeps out dirt and dust.

When dirt and dust get into the milk, bacteria are car-

ried with them, and these bacteria cause the milk to sour. The cleaner the milk, the longer it will keep. If milk is to be kept for use it should be cooled to as low a temperature as possible immediately after it is drawn from the cow. In order to be kept sweet for any length of time it must be kept clean and cool. Cooling the milk immediately and keeping it at a low temperature delays the growth of bacteria, which grow best under warmer conditions. If all milk containers and utensils are sunned regularly many bacteria will be destroyed, and the milk will keep better.

Separating Milk. We separate milk to get cream. Cream is made up of the same constituents as milk, but these constituents are in different proportions. Butter fat is the most important constituent of cream. Milk contains from three to six per cent of butter fat, while cream contains from ten to sixty per cent. The butter fat in milk and cream is in little circular masses called fat globules. These globules are lighter than the rest of the milk. When the milk is drawn from the cow and left undisturbed for a time, these fat globules float to the surface. When we skim off the top of the milk after it has set a while, we obtain cream. This is one method of separating.

The best method of separating milk is the use of the centrifugal separator. The milk is run into a bowl which is revolving at a high speed. During this process the heavier part of the milk, the skim milk, is forced to the outside, while the cream, the lighter part, is crowded to the center. In this way the skim milk and the cream are separated. The advantage of using the centrifugal separator is that it is possible to get most of the fat out of the milk, and the separation is more rapid and much easier. The skim milk is also in better condition for feeding calves and pigs.

The milk should be separated as soon as possible after it is taken from the cow. If it gets cold it will not separate well, and a large amount of the butter fat will be left in the skim milk. The separator must be turned at the proper speed, as prescribed in the directions, and should be washed and scalded each time it is used.

Butter Making. Cream that is to be churned is usually allowed to sour, or ripen, because it churns more readily and the butter has a better taste than that made from cream churned while sweet. After the cream has ripened properly it is brought to a temperature of 65 degrees in winter and 53 degrees in summer, and is then poured into the churn. For best results the churn should not be filled more than half full. If the cream is ripened properly and is brought to the right temperature, the churning should be completed in from thirty to forty-five minutes. The time to stop churning is when the butter begins to form in little lumps the size of a kernel of wheat or corn. One should then draw off the buttermilk and add as much water as there was buttermilk drawn off. The churn should be revolved several times, the water should be drawn off, salt should be added at the rate of one ounce to each pound of butter, the salt should be worked into the butter, and the butter should then be molded into prints.

The barrel churn will give better results than types of churns that contain inside fixtures. If a churn has many inside fixtures the butter from it will have a greasy appearance.

SILOS AND SILAGE

A quarter of a century ago very few people in this country knew what a silo was, and fewer still had ever seen one. To-day there are very few people who have not heard of the silo.

The silo is an air-tight structure used for the preservation of green fodders in their green, succulent condition. Fodder, when put up in the silo, is called ensilage or silage. The first method used for preserving the green forage consisted of ditches and trenches in the ground. The crops were placed in the trenches and covered with earth. In this way the air was excluded from the feed, and it was kept from spoiling.

Two good types of silo. The one on the right is a solid-wall concrete silo; the one on the left is a hollow-tile silo.

Kinds of Silos. Each year the silo is coming into more general use in every community in Kansas. Most of the silos are built above ground and are made from such materials as wood, cement, cement blocks, cement staves, steel, wood and plaster, brick, and hollow tile.

Some silos are built square or polygonal, but the round structure gives better satisfaction. Those built above ground have doors to aid in getting the silage out. Before the silo is filled, these openings are closed and made air-tight.

The silo is filled from the top, by a blower similar to the straw blower on a threshing machine, or by a carrier. The crop to be used for silage is cut into pieces from one-half to three-fourths of an inch in length, so that it will pack thoroughly, and so that all the air possible will be ex-

cluded from the silo. Too much air in the silage will cause it to mold or decay.

Silage is preserved by the formation of acids, not by cooking or heating, as is often stated. The acids are formed by bacteria which grow under conditions unfavor-

Filling a silo. A blower is used to elevate the material from the cutter to the silo.

able to molds and to decay-producing bacteria. The sour taste of silage is due to the acid which preserves the feed.

The Pit Silo. Silos are sometimes built under ground. Such silos are called pit silos. The pit silo must be located in dry and well-drained ground, and is therefore not well adapted to the eastern part of Kansas, but in western Kansas, where the ground is dry and firm, this type of silo has proved very satisfactory. While the above-ground silo is usually to be preferred because of the ease with which the silage can be removed, the pit silo nevertheless

has some advantages. In the first place, it can be built with but little outlay of money, the principal item of expense being the labor required to dig the pit. Second, such a silo is easily constructed and requires very little skilled labor in building. Third, it can be filled with a silage cutter without the use of a blower.

The pit silo should be convenient to the place where the silage is to be fed. It is often possible to dig it at the end

A pit silo in western Kansas. The method of removing silage from the silo is shown in the picture.

of the barn, and build a shed over it. The silage can then be removed and distributed with a carrier similar to the common hay-carrier equipment. It is not advisable to build pit silos too large, and especially too deep, because the labor of digging and removing the silage increases with the depth. When a large storage capacity is needed, several small silos are better than one large one. A circular silo is most satisfactory and most economical to

build. It should be built with a cement curb six inches wide encircling the top. The curb should extend a few inches above the ground and into the ground a little below the frost line. This prevents surface water from entering the silo and also prevents the ground from caving into the silo around the top. The walls of the silo below the curb should be covered with a coat of plaster from three-fourths of an inch to one inch thick and then washed with a cement coat to make them air- and water-tight. The walls must be absolutely perpendicular and smooth so that the silage will settle uniformly. The silo should be provided with a good cover that will keep out trash and dirt and that will prevent children and animals from falling in. The top should be so constructed that it will provide for free circulation of air within the silo.

Care should be taken not to enter a pit silo if it is filled with carbon dioxide gas. When silage ferments, carbon dioxide gas is formed. This gas is heavier than air and will sometimes remain in the bottom of the silo. If it is present in sufficient quantities, a person descending into the silo will be suffocated. The presence of gas can easily be detected by lowering a lighted lantern into the silo. If the light goes out, it is an indication that gas is present. If gas is present, it can usually be removed by dropping a few bundles of hay or fodder into the silo and thus creating air currents. There is more danger of gas poisoning shortly after the silo is filled, but one should never enter a pit silo without first testing for gas.

Feeding Silage. When fed, silage is taken off the top each day, and must be taken from the entire surface of the silo, else the silage will spoil and be unfit for food. The best crops for silage are corn, kafir, and sorghum, followed by milo, oats and peas, cowpeas, rye, and alfalfa. These crops are put into the silo a few days before they

are ripe enough for harvesting. They are not cured in any way, but are put up in their green state. The silo enables one to preserve the entire corn crop in excellent form for feeding. The stalks and leaves of corn contain almost one-half of the feeding value of the entire corn plant. The other portion of it is in the grain. When the grain is harvested and the stalks are left in the field, about one-half of the entire crop is wasted.

The silo furnishes the best method possible for storing and feeding the fodder. When made into silage, the fodder is easily handled and fed. There are no cornstalks to be hauled out of the barnyard or to be broken down in the field before plowing.

When crops are put into the silo they furnish a green food for the winter, and this will serve the same purposes that the green grass serves in the summer. In this way farm animals can be furnished with the best of feed during the entire year. Silage, when fed to dairy cows, causes them to produce more milk; fed to beef cattle, in connection with other feeds, it causes rapid and economical gains. It is a good feed for sheep, and horses and hogs eat it readily.

Silage takes the place of pasture during the dry summer months. A cow usually eats thirty to forty pounds of silage a day. Every farmer who has more than seven cows should own a silo. A table in the Appendix shows the sizes of silos and the amounts of silage required for given numbers of cattle.

QUESTIONS

1. What is the importance of selecting the cows for the dairy?
2. What are the two methods used in selecting cows? Which method is better?
3. How can we account for the modern dairy cow's having dairy type? How does the typical dairy cow differ from the beef animal?

4. What is indicated by each of the following characteristics of the dairy animal: a large barrel; large milk veins; soft skin and hair?

5. What is the best way to keep the records of the milk and butter produced by a cow?

6. If a cow gives 40 pounds of milk per day and it tests 4.6 per cent butter fat, how much butter fat does the milk contain?

7. Maid Henry, a Holstein cow at the agricultural college, produced in a year 19,600 pounds of milk that tested 3.65 per cent butter fat. How much butter fat did she produce during the year?

8. Name the principal breeds of dairy cattle. How do they rank as to quantity of milk given? as to quality of milk?

9. Describe the Jersey cow typical of the breed; the Guernsey; the Ayrshire; the Holstein.

10. Under what conditions should a cow be fed grain while she is on grass?

11. How may a green, juicy food be provided for the cows during the winter months?

12. Why is it a poor practice to feed all milk cows alike?

13. State three points that must be kept in mind in building a barn for cows.

14. How does dirt get into the milk? How can this be avoided?

15. What two things must be done if the milk is to keep sweet for any length of time? Why should milk be kept cold?

16. Why do we separate milk? What is the best method of separating? Why does cream come to the top of milk?

17. Why is cream soured before it is churned? When is the proper time to cease churning? What is the best kind of churn? Why?

18. What is a silo? What is silage? What materials are used in building silos? How is a pit silo built?

19. How is a silo filled? Why is the feed cut before it is put in the silo? Why does silage keep?

20. To what animals may silage be fed with advantage? What are the advantages of a silo? What are the best crops for silage?

CHAPTER XXVI

POULTRY

The value of the meat and eggs produced by poultry in the United States in one year is about equal to that of all the gold, silver, iron, and coal mined in the United States in the same length of time.

Kansas stands fifth among the states of the Union in number of fowls of all kinds kept on farms. The states that lead her are Iowa, Missouri, Illinois, and Ohio. In the value of her poultry Kansas stands seventh, being exceeded by New York and Pennsylvania in addition to those which lead in the numbers kept. The reasons these two states having fewer fowls lead Kansas in the matter of value is that much more attention has been given to keeping only pure breeds of poultry and giving them good care, and that proximity to the markets causes better prices to be obtained. The value of all the poultry and eggs sold or consumed in Kansas in one year is probably between $30,000,000 and $40,000,000.

Kinds of Poultry. The tame birds which are raised for the purpose of supplying meat and eggs are spoken of as poultry. The most common kinds are chickens, turkeys, ducks, geese, guinea fowls, and pigeons. Ninety-five per cent of all the poultry in the United States consists of chickens, and this figure holds very nearly true for Kansas.

How Poultry is Named. There are four kinds of names used in naming poultry. These are:

1. The species name.
2. The class name.
3. The breed name.
4. The variety name.

TABLE SHOWING THE CLASS, BREED, AND VARIETY NAMES OF THE COMMON SORTS OF POULTRY.

Poultry	Chicken	Asiatic	Brahma	Light. Dark.
			Cochin	Buff. Partridge.
			Langshan	Black. White.
		Mediterranean	Leghorn	S. C. Brown R. C. Brown. S. C. White. R. C. White.
			Minorca	S. C. Black. R. C. Black. S. C. White.
		American	Plymouth Rock	Barred. White.
			Wyandotte	White. Silver-laced. Columbian.
			Rhode Island Red	S. C. Red. R. C. Red.
		English	Orpington	Buff. White. Black.
	Turkey	Turkey	Turkey	Bronze. White. Buff.
	Duck	Duck	Pekin	White.
			Rouen	Colored.
			Indian Runner	Fawn and White White.
	Goose	Goose	Toulouse	Gray.
			Emden	White.

As may be seen in the accompanying table the species name tells what kind of poultry is meant. Of all kinds except chickens the species and the class names are the same. In the case of chickens, however, the class name of the common sorts tells whence the chickens first came. Those belonging to the Asiatic class were first brought to this country from Asia. The Mediterraneans came from the country surrounding the Mediterranean sea. The English and the American classes originated in England and America, respectively.

Black Langshans (Asiatic).

Each class is divided into several breeds. A breed is a group of birds having the same shape, and the breed name refers to all the birds having that shape. It is the shape name. Brahmas are a group of chickens which first came from Asia, and which have a characteristic shape. Toulouse geese are geese having a certain shape, which has been named Toulouse.

Barred Plymouth Rock Male (American).

It will be noticed in the foregoing table that turkeys are all of one breed. This is because they are all of the same shape, so that the species, the class, and the breed names are the same.

The variety name may be thought of as the color name. So we have Light and Dark Brahmas; White, Brown, and Buff Leghorns; Bronze, White, and Buff Turkeys. Some-

White Plymouth Rocks and Rhode Island Reds

times, however, birds of the same shape and color have different kinds of combs, as have the Single-Comb and the Rose-Comb White Leghorns. In such cases the variety name includes both comb and color name, as in the case of the Single-Comb White Leghorn.

It is customary to use only the breed and the variety name in speaking of any sort of poultry; as, Light Brahmas, or Toulouse geese. Where the variety name distinguishes the kind of comb as well as the color it is customary to shorten the written name by using the letters S. C. and R. C. for Single-Comb and Rose-Comb; as, for instance, R. C. Brown Leghorns.

Much of the poultry found on Kansas farms is a mixture of several breeds or varieties. Such stock is referred to as scrub or mongrel stock, and has no name besides that of the species.

Houses for Poultry. While houses are not necessary for turkeys or geese, it pays to build a good house for ducks and chickens. All that is needed for turkeys and geese is some sort of rough shelter for the severest weather. It is not necessary to build so expensive a house for ducks as for chickens, because ducks are more hardy and can stand cold and lack of sunshine better.

The necessary conditions of a duck house are dryness, freedom from drafts, and cleanliness. The floor of the duck house where only a few are kept, should be well bedded with straw, and should be cleaned out as soon as the straw becomes matted and damp.

Dryness is even more important in a chicken house than in a shelter for ducks, for chickens take diseases very much more easily than do ducks, and dampness is favorable to the development of disease germs. Because sunlight kills germs, there should be plenty of windows on the south side of the hen house, so that plenty of sunlight can get in.

Chickens take cold very easily if they are in a draft, consequently it is best to have most of the openings on one side of the building, making the other sides tight, so

A good farm poultry house.

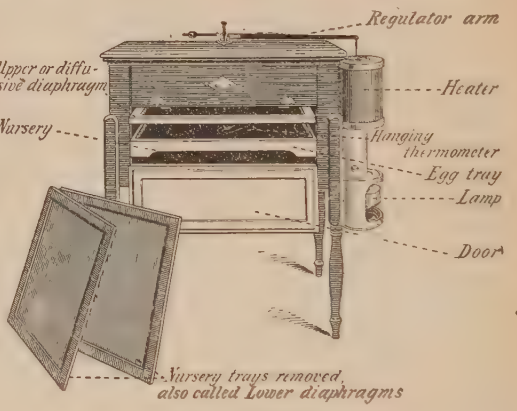
there may be no chance for drafts. Some of the openings should be covered with glass, like ordinary windows, but most of them should be covered only with cheesecloth on frames. These cloth coverings can be lowered when it is stormy, but should be kept open most of the time, so that there will always be plenty of fresh air in the house. The health of chickens is very dependent on fresh air.

Saving Eggs for Hatching. Eggs that are to be used for hatching should be set as soon as possible after being laid. When for any reason it is necessary to keep them for a time before setting them, they should be kept in a cool, dry place and turned once every day.

Running an Incubator. The room in which an incubator is kept should have as nearly uniform a temperature

as possible. Generally a cellar is the best place, because in cool weather a living room is likely to be warm during the day and cool at night. The top of the incubator should be level. If one corner is higher than the rest the hot air will rise to that corner and make it warmer. This will cause the eggs in that part of the machine to hatch before they should, which will be likely to result in weak chickens.

After the lamp has been lighted the regulators should be adjusted until an even temperature of 102° or 103° is held on a level with the top of the eggs. In all parts of the state, except possibly the extreme eastern end, a pan of water with a good-sized sponge in it should be placed below the egg tray for the purpose of keeping the air surrounding the eggs moist. The incubator is then ready to receive the eggs.



A good type of incubator.

Beginning the third day, one should take the eggs out three times every day and turn them by moving them about in the egg tray gently with the hands. Once each day they should be left outside the incubator until they feel cool to some sensitive part of the body, such as the lips or the eyelids. This cooling corresponds to that which occurs when the hen leaves the nest to eat. It results in a better hatch.

On the seventh and fourteenth days infertile eggs and

those in which the chick shows unmistakable evidence of having died should be removed from the incubator. This gives more room for the chicks to hatch and prevents the dead eggs from spoiling and making the air surrounding the eggs impure.

The incubator should be run as outlined above until the eighteenth day, when the temperature may be allowed to reach 104, but must not go above 105. The turning and cooling should be stopped at this time and the door of the incubator kept closed until the hatch is over. Before the door is closed permanently, the moisture pan should be removed and the tray shifted so that the chicks may drop down into the space below the egg tray (called the nursery) as they come forward to the light.

Brooding. When it is necessary to brood chicks without hens, brooders are used. A brooder is a box or small house which is well-ventilated and which may be warmed to any desired temperature. When the chicks are first taken from the incubator the temperature under the hoverer (the warmest part of the brooder) should be about 100°. As the chicks grow and become covered with feathers this temperature should be reduced, care being taken, however, to keep the chicks comfortable at all times. If they are kept too warm they are likely to become ill with leg weakness. In severe cases the chicks become unable to walk at all. If they are kept too cool they will not grow as they should, and in case of severe chilling will die.

Besides being kept warm and well-ventilated, the brooder should be frequently and carefully cleaned.

Feeding Chickens. The feeding habits of chickens differ somewhat from those of other species of poultry, and very decidedly from those of other farm animals.

They do not need so much animal food as do ducks or turkeys, and are greater seed and grain eaters than either ducks or geese, which consume large amounts of grass and other soft herbage.

In comparison with other farm animals, their feed is very much more concentrated, being made up chiefly of grains and grain by-products. While they eat a good deal of green grass, they can not make use of dry hay or fodder as do the larger animals. They need a larger proportion of protein and mineral matter in their feed than do any of the larger animals. The extra amount of mineral is necessary to furnish material out of which to make egg shells. It also serves to grind the feed in the gizzard, as the feed is swallowed whole.

Dark Brahma Female (Asiatic.)

Kinds of Feed. Chicken feed is usually furnished mainly in two forms, called "scratching feed" and mash. The "scratching feed" is made up of whole or cracked grains, and is fed by being scattered in a deep litter of straw so that the birds will need to take a great deal of exercise in scratching it out. The mash is made up of ground material, like shorts, middlings, commercial meat scraps, oil meal, and cottonseed meal. This may be fed dry in hoppers made for the purpose, or may be moistened with milk or water and fed in troughs. Twice as much "scratching feed" as mash should be fed.

Supplements. To supplement these kinds of feed and

make them more useful, supplements, or accessories to the main ration, are fed. These are generally grit; shell or bone; charcoal; and green feed. Grit is made out of any hard mineral substance, like granite or flint, crushed into pieces about the size of grain. It aids the gizzard in grinding the feed. Shell or bone is useful in furnishing the material for the formation of bone in growing chicks and the egg shell with laying stock. It is made of oyster shell or bone ground to the proper size. Charcoal ground to the right size is readily eaten by fowls, and helps to keep them in good health by absorbing injurious substances from the digestive organs. Fresh, tender green food, like young grass, cabbage, and sprouted oats, is relished by chickens, adds variety to the feed, and helps to stimulate the appetite.

White Wyandotte Male (American).

Rations for Laying Hens. A good ration for laying hens of medium size (American and English breeds) is as follows: three parts of wheat; three parts of cracked corn; one part of oats. This is fed in connection with a dry mash made of 60 pounds of corn meal; 60 pounds of wheat middlings or shorts; 50 pounds of meat scraps; 30 pounds of wheat bran; 10 pounds of linseed-oil meal; 10 pounds of alfalfa meal; 1 pound of salt. Grit, shell, and charcoal should at all times be kept in hoppers before the birds, and all the green feed that the birds will eat up quickly should be fed them once a day.

A good ration for laying hens of the Mediterranean,

or lightweight, breeds includes a mash fed dry, consisting of corn meal, 3½ parts by weight; linseed-oil meal, 1 part by weight; wheat bran, 5½ parts by weight; wheat middlings or shorts, 3 parts by weight; meat scraps, 2½ parts by weight. The scratching part of the ration consists of whole corn and wheat in equal parts. The supplements to the ration should be furnished as before. During the winter silage may be given freely in place of green feed.

With both of these rations, the scratching feed is scattered in litter twice a day. In the morning a light feed is given, while at night the birds are given all they will eat. At noon the mash hoppers are opened, and left open throughout the afternoon. There is little danger of hens' overeating of mash; they prefer grain, and will generally be found eager for their evening meal of scratching feed. Green feed is also given at noon if the birds are shut up or the ground is frozen. Fresh water is given in the morning and at noon. In warm weather it should be given again in the evening.

Feeding Chicks. Little chicks should not be fed anything for at least forty-eight hours after hatching. The yolk of the egg is taken into the body of the chick just before it hatches, and supplies it with food for from two to three days. Chicks should not be fed until they show, by chirping loudly, that they are hungry. From that time on, they should be fed at least five times daily. The first feed may consist of the infertile eggs tested out of the incubator; hard boiled; and ground fine, shell and all, in a meat chopper; and mixed with about six times their bulk of rolled oats.

About the sixth day the following grain mixture may be fed: cracked wheat, 15 parts by weight; pinhead oatmeal, 10 parts by weight; finely cracked corn, 15 parts by weight;

finely cracked peas, 3 parts by weight; broken rice, 2 parts by weight; fine grit, 5 parts by weight; fine charcoal, 2 parts by weight.

As soon as the chicks can eat whole wheat and coarsely cracked corn they should be given these in place of the finely cracked grain.

When the chicks are weaned, or taken from the brooders, they may be fed by the use of hoppers if they have the run of the fields and pastures, because they will get abundant exercise chasing bugs and scratching for worms. Cracked corn, wheat, cracked bone, oyster shell, and grit may be placed in separate troughs, as may also the following dry mash mixture: wheat bran, 1 part by weight; corn meal, 2 parts by weight; wheat middlings, 1 part by weight; meat scraps, 1 part by weight.

Caring for Market Eggs. Eggs spoil so easily that they are classed, along with milk and butter, among "highly perishable products." Butter melts, and milk clabbers, if not kept cool. These conditions change their appearance and are easily noticed. An egg, however, may spoil completely and still have the appearance of a good egg. For this reason eggs are not cared for on the farm so carefully as are butter and milk.

In saving eggs for market one should try to keep them as fresh as possible. They lose their freshness by shrinking, incubating, growing watery, molding, and absorbing odors. All these defects increase with age, and eggs should therefore be sent to market just as soon after they are laid as possible.

When it is impossible to market them promptly, they should be placed in a room in which the temperature never goes above 68°. Most cellars give the proper temperature. The reason for giving special attention to temperature is that a fertile egg will begin to grow into a chick in any

temperature above 68°. The room where eggs are kept should also be dry and free from odors. If the air is damp, spots of mold are likely to grow inside the egg shell and make the eggs unfit to eat. If the cellar has a musty smell, or if the eggs are kept close to onions, decayed vegetables, and the like, the odors will be absorbed, and the flavor of the eggs will be affected. Besides being fresh, a really first-class egg must be clean, of good size, and free from cracks.

The raising of good poultry, with proper care of the birds and of the eggs, will improve the home table of the farmer and will at the same time give him an additional source of income. Poultry keeping proves also interesting and attractive to the boys and girls.

QUESTIONS

1. How does the value of meat and eggs produced by poultry in one year compare with the value of the gold and silver mined in the same period?
2. What is the rank of Kansas as a poultry state?
3. How is poultry named?
4. Tell the difference between a class, a breed, and a variety, and name the three most common American breeds.
5. What are the essentials in a poultry house?
6. On what days should incubator eggs be tested and at what temperature should an incubator be run? Where should an incubator be run?
7. What are the important conditions in artificial brooding?
8. How do chickens differ from other farm animals in their feeding habits?
9. What are the kinds of poultry feed?
10. Give a good ration for a laying hen.
11. Tell how little chicks should be fed.
12. Give rations for chicks before and after they are weaned.
13. Tell how to care for eggs so that they will reach market in first-class condition.

CHAPTER XXVII

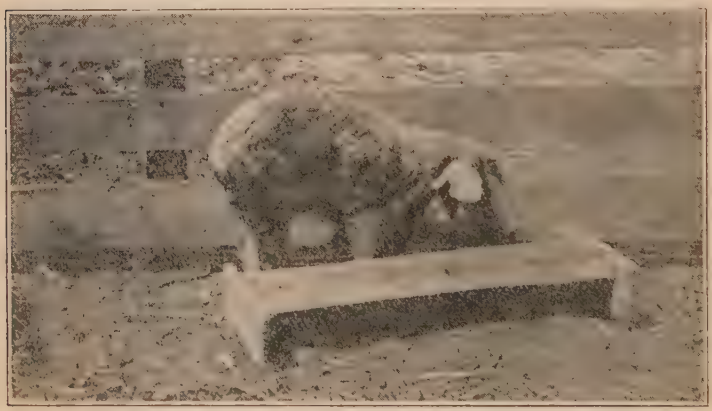
DISEASES OF LIVE STOCK

Animals, like men, have diseases. In many cases the same diseases may be given to both man and the lower animals. Man is afflicted, however, with some diseases which the lower animals do not contract, and likewise the lower animals are subject to some diseases with which the human family is not troubled. The body of the human being and that of a lower animal are made up of the same kinds of tissues and organs, and it is chiefly the difference in food and surroundings which makes the difference in disease.

What Causes Disease. So long as all the organs and all the tissues of the body perform their normal functions, the animal is healthy. But when any of the organs or tissues do not perform the work that nature intended they should, the animal does not thrive, but becomes ill at ease, or, as we say, diseased. If this condition goes on for any length of time the result may show itself in various ways, depending upon the parts affected and upon the cause of the trouble. Disease, then, may be said to be a departure from the state of health. So long as the animal eats the proper amount of clean, wholesome food and drinks a certain amount of pure water and breathes a certain amount of pure air, its tissues and organs perform the functions nature intended they should and the animal is considered healthy. Any interference from any cause results in what we call disease. An animal not given food enough, too much food, improper kinds of food, or food, air, or water that is not pure, will in time cease to thrive

or may even feel pain, which is a sign of disease. Sudden changes in the temperature of the air, too much cold, heat, sun, or rain, or a draft of air when the animal is weak or tired, or the entrance into the system of certain small organisms — any of these conditions help to cause disease. When these abnormal conditions are present the animal shows them in various ways, depending upon the parts affected and the severity of the cause.

Kinds of Diseases. Diseases of animals and man are usually divided into two classes. The one class comprises all those diseases which are occasionally met with at different times of the year and which can not be transmitted



Animals become diseased when forced to live on insanitary premises.

by the sick to the well. These diseases are called sporadic, or noninfectious, diseases. Examples of such diseases are rheumatism, colic, and paralysis. Infectious diseases are those which are caused by small organisms called germs and can be transmitted from the sick animal to the well ones. In this class are included such diseases as tuberculosis, or consumption, in both man and the lower animals;

diphtheria, typhoid fever, and smallpox in man; and hog cholera, rabies, and distemper in some of the lower animals.

How Diseases Spread. Infectious diseases are transmitted to other animals by germs. These are organisms most of which belong to the vegetable kingdom and which are too small to be seen except with a high-power microscope. Each organism can cause only one kind of disease. It is necessary that before any infectious disease can show itself or develop, the organism must be taken into the system. In other words, it is necessary to bring the germ and the animal together. If they are kept apart the disease can not spread. If the organisms were large enough to be seen with the naked eye it would be an easy matter to prevent the spread of diseases, but since they are so small that we can not see them they sometimes travel rather fast and far before we are aware of it. Some of them live and grow and are carried to healthy animals in water, some of them in milk, some in the dust. Some live only a short time outside the animal body. When a germ gets into the system of an animal it multiplies very rapidly, and germs are usually found in the blood and all the tissues of the affected animal in a very short time. Some of them are thrown off through every avenue in the body, frequently by the million, as they multiply very, very rapidly. It can be seen that if any animal is sick merely one day with an infectious disease, the whole yard, the barn, or the pen where the animal is kept may be infected. It would naturally then suggest itself that, wherever there is an infectious disease, the well animals should be taken away from the sick ones as soon as the trouble is discovered, and as many as possible of the organisms that escape from the sick animal should be destroyed.

Disinfection. An animal that has the organisms in its body is infected. Getting rid of, or killing, these organisms we call disinfection. We may disinfect the animal or disinfect the surroundings. Since the organisms are found usually in all parts of the body of an infected animal, it is hard to make a thorough disinfection of the animal, but we can disinfect the place in which the animal is kept, and keep the disease under control. Sunshine is nature's best disinfectant, and, wherever possible, the sun should be encouraged to shine into all rooms and pens in which disease exists. All straw, cobs, sticks of wood, and litter should be removed from the premises and burned, in order that the organisms may not be able to hide from the sun underneath these obstructions. Then, in order to destroy all organisms that may have begun to go into the ground or into fence corners or floors, these places should be thoroughly covered or sprayed with one part of crude carbolic acid to twenty parts of water, or with a three per cent solution of compound cresol. This should be used wherever there is the slightest chance for any of the organisms to hide. They like moist, shady places. Consequently, for thorough disinfection good drainage is necessary, and freshly slaked lime scattered every few days over the ground and floors where animals are kept will help very much to keep the premises free from germs.

When the organisms become so numerous in the body of an animal that they interfere seriously with the function of one or more of its organs, the animal becomes diseased, or sick. If the normal function is not soon restored, the death of the animal results. The whole body of this animal is filled with these organisms, which are spread in different ways to other animals. Persons walking through the premises where these germs are, or animals going through, or birds coming upon the premises, can carry

enough of the germs on their feet to give the disease to many other animals miles away. It can be seen how necessary it is to keep these organisms from getting away or from spreading to other animals. The main object should be to destroy as many of the organisms as possible and to keep the organisms and the healthy animals apart. This, of course, is accomplished by disinfection, and since the body of this dead animal is filled with these organisms

A lot like this breeds disease germs.

it should be burned immediately or buried very deep and covered with freshly slaked lime. The place where the animal was kept should be thoroughly disinfected, so that a healthy animal coming upon this place may not take the disease.

The general rule followed in disinfecting stables where diseased animals have been kept is as follows: Remove and burn all cobwebs, bedding in stalls, contents of the mangers, feed boxes, hayricks, and all loose and decayed woodwork in the stables, barns, or sheds where the affected animals have been. Thoroughly scrape and cleanse the floors, the sides, and the front of the stalls, as well as the mangers, feed boxes, stanchions, and hayricks, and thoroughly saturate them with a solution of carbolic acid

(six ounces of carbolic acid to each gallon of water), or with a three per cent solution of compound cresol. Then thoroughly paint or whitewash all exposed woodwork with a wash containing one pound of chloride of lime to each four gallons of water, enough quicklime having been added to make the mixture wash white. Scatter lime all over the floor, especially in the corners and in all damp places. The watering troughs and buckets must be thoroughly scalded, and rinsed with hot water.

The organisms of many diseases are found to increase in number in nearly all stables, pens, and yards. Distemper (catarrhal fever), lock-jaw (tetanus), some lung troubles, and one of the most deadly diseases of young foals, are some of the most common diseases the organisms of which are found in the horse stables and surroundings. All these diseases can be prevented by proper care. In the cattle barns, tuberculosis, lump-jaw (actinomycosis), and calf diseases develop if the premises are not kept clean, while around the hog lots the germs of cholera and tuberculosis are liable to be harbored for a long time.

A good plan is to clean and disinfect the whole premises thoroughly every spring and fall, following the foregoing methods. In this way fully ninety per cent of infectious diseases can be prevented.

QUESTIONS

1. Compare the general make-up of man and that of the lower animals. To what extent are man and the lower animals subject to the same diseases?

2. Under what conditions may a person or animal be said to be healthy? diseased?

3. What are some of the general causes of disease?

4. What are the two general classes of diseases? Name some diseases of each class.

5. How do infectious diseases spread?

6. What is necessary to prevent a person or an animal from taking a certain disease from another person or animal?

7. How many different diseases can a certain kind of organism produce?

8. How large are disease-producing organisms and in what parts of the animal are they usually found?

9. How do disease germs spread from one animal to another? How fast do they increase in number?

10. What is disinfection? Name some common disinfectants.

11. What should be done with the bodies of animals that have died of infectious disease?

12. How should you disinfect a building and yard?

CHAPTER XXVIII

GROWING AND CARING FOR TREES

Every forest tree grows from a seed or from a part of a twig or root called a cutting. A plot of ground devoted entirely to the growing of trees from seeds or cuttings is a nursery. A forest nursery is a nursery devoted entirely to the growing of forest trees until they reach a suitable size for planting in their permanent location for the production of posts, poles, or lumber.

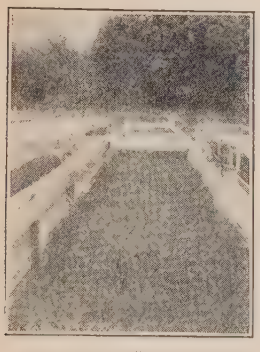
Forest trees are divided into two main groups, conifers and broadleaf trees.

The group known as conifers is composed of trees that bear cones. Conifers are usually known as evergreens, although some of the species of this group shed their leaves annually, as do the broadleaf species. Pines, spruces, firs, hemlocks, larches, cypresses, cedars, and others comprise this group.

The broadleaf species are known also as hardwoods. The group is made up of species that differ from the conifers in the shape of the leaves. All of them have leaves more or less wide, rather than needlelike, as are the leaves of the conifers. The trees composing the broadleaf group shed their leaves annually, with the exception of a few, known as broadleaf evergreens, which are represented by the live oak, the holly, and the magnolia.

Conifers. Seeds of the conifers are sown in well-prepared beds covered with a lattice roof that protects the seedlings from the direct light of the sun, and from wind, hail, and dashing rain.

The seeds are sown in April or early in May. Under favorable weather conditions, they begin to come up in about a week. At the end of the first season's growth they vary from two to six inches in height, depending upon the species, the young seedling trees from small seeds being smaller than those from large seeds.



Coniferous seedlings in the State Forest Nursery. The shade frames have been removed to allow the seedlings to be seen.

At the age of one or two years these seedlings are transplanted to rows in the open, which are spoken of as nursery rows. In these rows they are planted six or eight inches apart, and are allowed to grow for one or two years, until they reach a suitable size for permanent planting.

Broadleaf Trees. The broadleaf species do not require so much protection from sun, wind, rain, and hail as do the conifers, and they are usually grown in rows in the open. They make a much stronger growth.

The seeds may be planted either in the fall or early in the spring. The rate of growth of the seedlings depends largely on the size of the seeds. The larger the seed, the more rapidly the seedling will usually grow. At the close of the season's growth the seedlings will vary from six or eight to thirty inches in height. The largest of these may, when one year old, be set in the permanent planting. The smaller plants must be allowed to grow in the nursery until they are two or three years of age. They are usually transplanted once while in the nursery.

Nut-bearing trees are seldom grown extensively in nurseries. The trees can usually be grown more successfully if the nuts are planted in the permanent site where

the trees are to grow to maturity. These species all develop a strong taproot and but few lateral roots; consequently, they are difficult to transplant successfully.

Cottonwoods and willows are propagated entirely from cuttings, which are sections of wood of the past season's growth, varying from ten to fifteen inches in length. These are planted in well-prepared ground in the nursery,

Catalpa seedlings in the State Forest Nursery.

to grow until of suitable size for permanent planting. These two species are propagated in this manner because their seeds are so small and so hard to gather and plant that propagating by seed is very difficult.

Under favorable weather conditions cuttings take root rapidly and make a very vigorous growth. At the end of the first season they vary from three feet to six or eight feet in height, and at the age of one year are of suitable size to be set out permanently.

The Size of Trees for Planting. Small trees should be used in extensive plantings, such as farm wood lots and windbreaks. Where so many are planted it would cost altogether too much to plant large trees. If conifers are to be planted, young trees two or three years old and from ten to fifteen inches in height should be used. They can

be planted and protected a great deal more cheaply than larger trees, and a larger proportion will live after being planted.

If broadleaf species are used, trees from three to five feet in height and from one-half to three-fourths of an inch in diameter are usually most satisfactory. Smaller trees suffer more in the planting than do trees of this size. Larger trees are objectionable because of their greater cost and the greater expense incurred in planting them.

One-, two-, and three-year-old ash trees. The three-year-old tree is a good size for wood-lot and windbreak planting. The others are too small.

For yard, street, or roadside planting, where only a few trees are to be set out, larger trees should be used. Conifers from two and one-half to four feet in height are the most desirable, and broadleaf species should be eight or ten feet in height and one and one-half or two inches in diameter.

How to Plant a Tree. The first step to insure the successful growth of the newly planted tree is to be sure that the tree is in good condition when it is planted. The tree must, therefore, from the time it leaves the nursery until it is planted, be properly handled to prevent injury by exposure of its roots. Nurserymen familiar with their business understand how to pack and handle trees without exposing them unduly, and the planter should be careful to secure his stock from the grower, rather than from tree peddlers or other irresponsible persons.

On receiving trees from the nursery, one should keep them in a cool, moist place until they are planted. The first step in the actual operation of planting a tree is the

preparation of the ground for planting. Trees require a loose, mellow soil. The hole in which a tree is to be set should be dug wide enough to receive the roots in their natural order, and deep enough to allow the tree to be planted two or three inches deeper than it grew in the nursery. In the bottom of the hole, there should be one or two inches of loose soil in which to bed the roots. After covering the roots with two or three inches of mellow soil, one should tramp it firmly over them to insure close contact of soil and roots. An inch or two of the top soil should be left mellow, to serve as a mulch.

If the ground at the time of planting is in good condition it is not necessary to pour water over the roots of the newly planted tree. In case the ground is dry, the hole should be filled with water one or two days before the tree is to be planted. If water is poured on dry soil over the roots of a newly planted tree it forms a puddle, which, on drying, shrinks and allows air passages to form. The entire body of earth around the roots is thus dried to such an extent that more injury is caused to the tree than would have occurred if no water had been applied. If the water is poured into the hole prior to the time of planting the tree, the trouble mentioned will be avoided.

This method of planting applies to the conifers as well as to the broadleaf species.

The Time of Planting. Best results are secured by planting trees as early in the spring as the soil and the climatic conditions will permit. Trees begin their growth very soon after the frost goes out of the ground. The exact time for planting varies with the seasons, but trees should always be planted before the buds begin to burst.

Cultivation. The successful growth of trees depends almost as much upon the care and cultivation that they

receive as upon the manner in which they are planted. Trees require moisture in order to maintain life. This moisture must be secured from the soil, and any cultivation that will conserve the soil moisture is beneficial to the tree. Trees respond as readily to cultivation as do any growing plants. Cultivation conserves moisture by preventing a growth of weeds which would use water that is

A wood lot having nearly a full stand of thrifty, well-developed trees of desirable species.

needed by the tree. It also maintains a soil mulch, which prevents surface evaporation. Cultivation keeps the surface soil in a receptive condition for the moisture that falls in the form of rain and snow. Cultivation must be continued until the trees reach a sufficient size to shade the ground and protect themselves.

Protection. Newly planted evergreens must be protected against injury by sun and wind. When planted, these trees are in full foliage, and are liable to injury on

account of excessive transpiration from the leaves, due to the drying effect of the wind or to the intense heat of the sun. Ample protection from these sources of injury can be provided by two boards driven in an upright position a

A newly cut-over wood lot that should be planted in black walnut, catalpa, cottonwood, or bur oak. The land is subject to occasional flooding and can not be used for growing grain crops.

few inches back from the tree, on the south and west sides. These boards should be from six to eight inches wide, and, when driven into the ground, fully as high as the tree. Broadleaf trees are not so liable to suffer from wind and sun.

All young trees, however, are subject to injury by animals browsing upon them or trampling the ground about them. Animals of all descriptions must be excluded from the ground on which trees are being grown.

During the winter months young trees are constantly in danger of being girdled by rabbits. For protection against this, the trees should either be wrapped with some

protective covering, or be painted with a solution of common lime and sulphur. Frequently it is more practical to trap or poison the rabbits, or even to inclose the trees with a rabbit-tight fence.

Trees Suitable for Kansas. Kansas is a large state, and soil conditions and rainfall vary so greatly that a list of trees suitable for planting must be varied to suit the different conditions.

In the matter of tree growth the state should be divided into two parts. The eastern part should include that portion of the state where the annual rainfall is twenty-five inches or more. To this region the following trees are best adapted:

Rock (sugar) maple.	Sycamore.
Red oak.	Black cherry.
Bur oak.	Kentucky coffee tree.
Pin oak.	Thornless honey locust.
Hackberry.	Basswood (linden).
White elm.	Green ash.

The evergreens suitable for the same part of the state are:

White pine.	White spruce.
Norway pine.	Norway spruce.
Table Mountain pine.	Douglas fir.
Western yellow pine.	White (silver) fir.
Austrian pine.	Chinese arbor vitæ.
Scotch pine.	Bald cypress.
Swiss Mountain pine.	Red cedar.
Colorado blue spruce.	Dwarf juniper.

The land in the western part of the state may be divided into two classes. The first class comprises the heavy loam soil. Trees suitable for planting in this soil are:

Thornless honey locust.	Osage orange.
Hackberry.	Red cedar.
White elm.	Chinese arbor vitæ.
Green ash.	Scotch pine.
Russian wild olive.	Austrian pine.

The second class includes the sandy lands composed of the sand-hill formation, and all the sandy soils along the river channels. The trees suitable for this class are:

Hackberry.	Red cedar.
White elm.	Chinese arbor vitæ.
Russian wild olive.	Austrian pine.
Russian mulberry.	Scotch pine.
Cottonwood.	Jack pine.

The conifers named in the foregoing lists are well suited for windbreak, shelter-belt, and ornamental planting, while the broadleaf species are well adapted for shade purposes.

In the eastern division of the state the hardy catalpa and the Osage orange are best adapted for post and pole production, while the cottonwood, the black walnut, and the bur oak will yield a greater cut of lumber than any of the other trees. In the western division of Kansas the honey locust, the Osage orange, and the Russian mulberry may be used for post and pole production, and the cottonwood for lumber production.

QUESTIONS

1. From what sources are forest trees propagated?

2. At what seasons of the year may forest tree seeds be planted?

3. Why is it necessary to grow seedling trees in a nursery? Give as many reasons as possible.

4. For how long a time are trees grown in the nursery?

5. What size of tree should be used (1) for evergreen windbreak or wood-lot planting; (2) for broadleaf windbreak or wood-lot planting; (3) for evergreen ornamental planting; (4) for broadleaf yard, street, and roadside planting? Give reasons.

6. What care must be taken in handling the trees from the time they leave the nursery until they are planted?

7. Give in detail each step in planting a tree. What special care must be taken in each step, and why?

8. What cultivation is necessary to secure a successful growth of newly planted trees? Give reasons why cultivation is necessary.

9. Why is it necessary to protect newly planted evergreens from the wind and the sun? Describe the method of protecting the newly set trees.

10. Make a list of five broadleaf trees suitable for wood-lot planting in your home community.

11. Make a list of five broadleaf trees suitable for yard, street, or roadside planting in your home community.

12. Make a list of four coniferous evergreen trees suitable for windbreak or ornamental planting in your home community.

CHAPTER XXIX

PLANT DISEASES

Many plants of the farm and garden become sick or diseased and never grow into strong and healthy individuals. They die or their products are so diseased that the market value is greatly lessened.

There are scores of plant diseases in Kansas, some of which cause a large loss. The sorghum smut disease alone caused Kansas farmers to lose more than a million dollars in 1912. The wheat and oat smuts, corn smut, the apple blotch, and the dry rot of potato are other plant diseases which are found in Kansas and which cause large losses every year.

Kinds of Diseases. The diseases of plants are due to various causes, such as parasitic plants, unfavorable climatic and soil conditions, and even injuries by animals or man. The first of these is by far the most common and important, and only diseases produced by parasitic plants will be considered here.

Diseases Due to Parasitic Plants. A parasitic plant is one which can not obtain its own food from the soil and air, but grows upon and gets its nourishment from some other living plant. The plant upon which the parasite lives, called the host, often becomes diseased, because it is robbed of its proper share and kind of food and its mode of life is interfered with.

Parasitic plants may be divided into two groups: flowering plant parasites; bacteria and fungi.

Flowering Plant Parasites. Common examples of flowering plant parasites are the dodder and the mistletoe. The dodder, or "love vine," is widely spread in Kansas. It is a long, twining plant, yellowish in color. It wraps itself around the stems of clover and alfalfa, and by means of little suckers extracts the plant juices for its food. This parasite is very injurious to the plants attacked, and often is a serious pest in fields.

Mistletoe, with its pretty white berries—a plant which we see at Christmastide—lives a similar parasitic life on trees. It extracts the juices from the branches by means of rootlike suckers. This pest occurs in parts of southeastern Kansas on ornamental and forest trees.

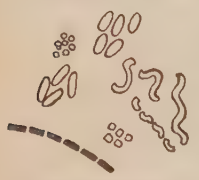
Dodder on alfalfa. The picture shows the parasite's twining habit of growth. The dodder is in full bloom. (After Stewart.)

Bacteria and Fungi. Bacteria and fungi form a very large group of plants which do not have flowers, leaves, stems, or roots. They have no green coloring matter, or chlorophyll, such as is found in the leaves of the flowering plants, and are generally white, yellowish-brown, or black—never green.

Because fungi and bacteria do not have this green color, which is the machinery of other plants for manufacturing food from the raw materials of air and soil, they can not prepare their own food. They therefore depend upon other plants or animals, either living or dead, for their nourishment. Those fungi and bacteria which get their food from living plants we have called parasites, while those which live upon dead plant or animal matter are called saprophytes.

Mistletoe on elms near Coffeyville, Kansas. (After Scott.)

Bacteria, or germs, as they are sometimes called, are the tiniest plants known, and it is necessary to use a very strong magnifying glass, or lens, to see them. It would take four hundred of the spherical bacteria placed side by side in a row to equal in length the thickness of this paper. They are found everywhere—in the soil, the air, the water, plants, and animals. They multiply by splitting into two equal parts, or cells. Each of these is again divided into two cells, and so the process continues. Sometimes it takes only half an hour for these little bacteria to split in two. In this way a very large number can be produced in a day.



Typical bacteria, magnified two thousand times. Some are spherical, some oblong, some rod-like, and others spiral.

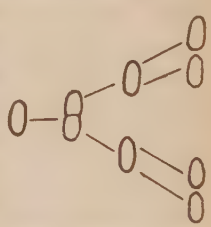
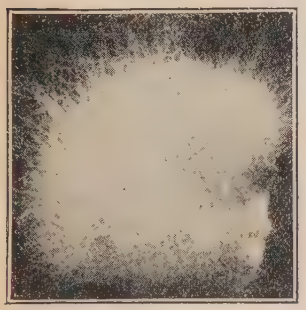


Diagram showing how bacteria multiply.

Most bacteria do not cause plant diseases, and some are very useful. One kind, as we have learned, lives in the roots of clover and alfalfa, and gathers plant food, known as free nitrogen, from the air. This is used to some extent

by the host plants. Some bacteria, however, are very harmful, causing diseases such as pear blight and cucumber wilt.

Fungi also are small plants, but not so tiny as bacteria. Sometimes it is necessary to use a magnifying glass to see them. They grow as saprophytes on dead matter, such as rotting wood, stumps, stale bread, jelly, and cheese, or as parasites on living plants. Like bacteria, they do not have true roots or leaves, but in place of these is a mass of thread-like bodies, called mycelium, by means of which they absorb their food. Fungi do not have true seeds like flowering plants, but in their place have very tiny bodies called spores. These are so small that they can not be seen without a microscope, unless they are in large masses. The spores are scattered about by the wind, the water, insects, man, and other animals, and if they fall in damp places they grow. Molds, mushrooms, puffballs, corn smut, and wheat rust are good examples of fungi.



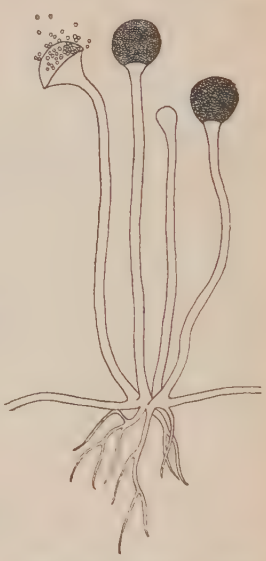
Mycelium. Natural size.

Most plant diseases are caused by fungi. The rusts of wheat and oats, the smuts of wheat, corn, and sorghum, scab on potatoes, blotch on apples, brown rot on peaches, and the alfalfa leaf-spot disease, are well-known examples.

Not all fungi, however, cause disease. Among those which do not may be mentioned bread mold, yeast, toadstools, and puffballs.

How a Simple Fungus Lives. Bread mold is one of the simplest of fungous plants. Its spores occur everywhere in the air. When they fall on moist bread they grow, pro-

ducing a white, cottony mass of thread-like filaments. On the ends of some of these are found little sack-like bodies. These sacks look black because they are filled with thousands of gray spores, which, when the little sacks break, escape and are scattered in the air. If these spores fall upon moist bread they grow, and again produce a white, cottony mass. Many of the fungi that produce diseases live just as simple a life as does the bread mold. It is very necessary to know how they live before methods of preventing diseases caused by them can be devised, as their manner of life determines very largely which of several methods of prevention is most useful. Some of the methods of prevention, and examples of diseases controlled by each method, are given hereafter.



Bread mold, showing sack-like bodies containing the spores, or "seed," of the fungus. Highly magnified.

Pruning. Some diseases can be best controlled by cutting out and burning all diseased parts. If such a disease gets a good start the whole plant may have to be destroyed. The pear blight, the blister, or Illinois apple-tree canker, and the black knot of plum and cherry are well-known examples of such diseases, the first being caused by bacteria and the other two by fungi.

The Pear Blight. The pear blight, known also as fire blight, attacks pear, apple, and quince trees. It causes a wilting and blackening of the flowers and the young tips of the twigs. Sometimes the pears or apples are half grown before this disease causes them to dry and shrivel

up into so-called "mummies." Bees and other insects visit diseased trees and get the bacteria on their feet, then fly to the blossoms of healthy trees and leave some of the bacteria inside the flowers. These flowers become infected and die, and the bacteria work their way into the plant juices, clogging the food channels in the twigs. Diseased twigs wilt and finally die. Some of the bacteria live over winter in the twigs, and in this way carry the disease over from year to year. To control the disease it is necessary to destroy all sources of infection. Diseased twigs, limbs, and "mummies" must be collected and burned, and sometimes whole trees must be destroyed.

A pear twig affected by pear blight.

Spraying. There is no cure for fungous diseases. By spraying, some material poisonous to a fungus spore is spread as a thin film on the foliage of plants for protection. Germinating spores which come into contact with this poison are killed. Spraying, therefore, is a safeguard against disease rather than a cure. Three diseases common in Kansas, which may be controlled by spraying, may be taken as examples.

Early Blight of Potatoes. The early blight of potatoes is caused by a fungus which produces "target-board," or "frog-eye," markings on the surface of the leaves. The

leaves die early, and later the vines dry up. Sometimes fifty per cent of the potato crop is lost on account of this fungous disease. It does not, however, cause the potato tuber to rot, as does another blight known as the late blight of potatoes. Spraying the plants with Bordeaux mixture several times during a season will prevent both the early and the late potato blight.

Potato foliage affected with early blight, sometimes known as "frog-eye" or "target-board."

Apple Blotch. Apple blotch very frequently injures unsprayed apples in Kansas. It causes a more or less hard, jagged brown spot on the fruit, which sometimes cracks as a result. On the leaves it forms very small yellowish or white spots. The bark on the limbs becomes cracked and scaly. Often a cracked, roughened, ring-like area, called a canker, is formed on one side or surrounding the limb. Twigs, when diseased, show cracks in the bark. Spraying with Bordeaux mixture two or three times a season is a common preventive.

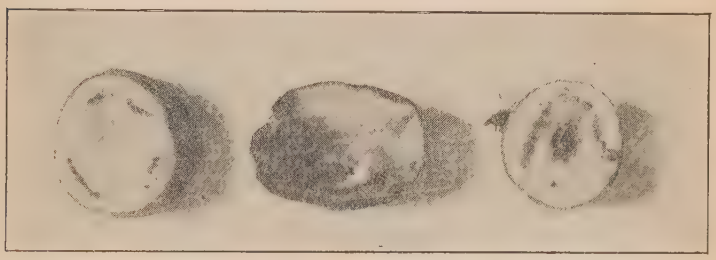
The Brown Rot. The brown rot attacks the peach, the plum, and the apple, causing a soft rot. It can be controlled by careful spraying with Bordeaux mixture or lime-sulphur wash.

Brown rot of peaches on picked fruit. (After Scott and Ayer.)

Crop Rotation. Some disease-producing fungi live in the soil from one year to another, and if the same crop is grown on the land successively it may become sick. When the soil becomes infected with such fungi it is necessary to change the crop grown on the land until the disease

disappears. This often takes several years, and a good crop rotation is necessary.

Dry Rot of Potatoes. Dry rot of potato, or stem blight, one of the worst potato diseases in Kansas, is caused by a



Potato tubers affected with dry rot. The tubers are cut in two. Observe the dark areas within the rind.

fungus which may live in the soil. When potatoes are grown on infected land the parasite gains entrance into the healthy plant through the roots, from which it spreads to the stem and leaves. Plants which are diseased wilt and lie limp upon the ground. The new potatoes become infected through the stems upon which they are growing, and the diseased tubers, when cut in two, show a black ring a little inside the rind. The fungus may live in the soil for several years, and it is necessary to grow some crop other than potatoes on infected land.

Other diseases which, like the dry rot of potato, may live for years in the soil, are cotton wilt, flax wilt, root rot of tobacco, cabbage yellows, and wilt of cowpeas.

Seed Treatment. Some diseases are carried over from year to year by means of fungus spores clinging to the seed. These diseases can often be prevented by treating the seed, before planting it, with formalin, copper sulphate, or some other solution that is poisonous to the spores but will not injure the seed. Immersing the seed in warm

water and raising the temperature until the spores are killed while the seed is left uninjured, is also a common preventive. Potato scab and some of the common smuts of grain may be prevented by seed treatment.

Smuts of Grain. The stinking smut of wheat, sometimes called bunt, is one of the worst diseases of wheat in Kansas. It is caused by a tiny colorless fungus, which lives inside the growing wheat. When the wheat plant is full grown the seeds do not develop as they should, but in their place is formed a smutty or powdery mass of spores, known as a smut ball. At threshing time, and in handling the wheat in sacks, bins, and machinery, the smut balls break very easily, and the smut spores are scattered over the healthy seed. When such seed is planted in the spring the tiny smut spores, which often are lodged in the crease or brush of the kernel, germinate, and a little smut plant enters the wheat plantlet and gets a foothold before the wheat appears above the ground. Here the parasite leads a hidden, satisfied life until the flowering time of the wheat, when, in place of sound seed, smut balls once more are formed.

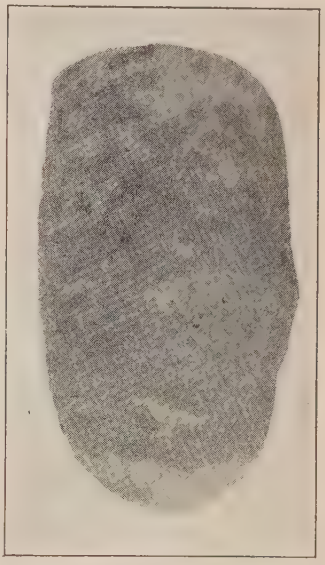
Wheat affected with stinking smut. Notice the spreading of the glumes due to large smut balls where sound kernels should be. Smut balls, whole and cut in two, may be seen on the right. (After Johnson.)

The covered smut of barley, the smut of oats, the kernel smut of sorghums and broom corn, and a smut of millet live in much the same way. All of them can be prevented by proper seed treatment.

Two other smuts, known as the loose smut of wheat and the loose smut of barley, are also very common in Kansas. Their mode of life is similar to that of stinking smut, but not identical with it, and they can be prevented only by very careful treatment of the seed with hot water.

Corn smut is related to the smuts already described, but is not carried from year to year on the seed. Its spores are scattered by the wind, live over winter outside, and infect the growing corn plant in the spring. Seed treatment has no effect on corn smut.

Potato Scab. Potato scab is recognized by the rough pitting of the seed, or the "scabby" appearance of the tubers. Young potatoes show the scab very plainly. When the tubers become older they frequently are deeply furrowed or cracked. Potato scab attacks only the tuber, not the leaves or stalks of the plant. If scabby potatoes are planted a scabby crop may result. Treating the uncut potato tubers with a formalin solution will help prevent this disease.

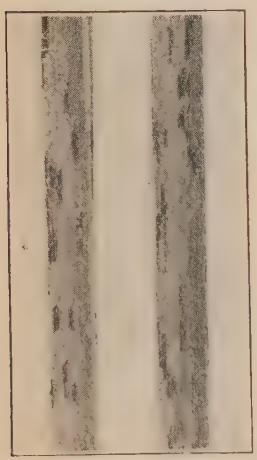


A potato tuber affected with scab. (After Corbett.)

Resistant Varieties. There is great difference in the ability of individual plants and of different varieties of plants to resist disease. Sometimes a single plant out of an entire field of sick plants remains healthy and produces seed. Such a plant is said to be resistant to the disease. If

seed from such healthy plants is collected and sown the next year, the resulting plants may also be resistant. By such selection, new resistant strains may be originated. This has been done in the case of cotton, cowpeas, cabbage, and other plants. Certain varieties also are naturally resistant to diseases. Among these may be mentioned the durum wheats, which are naturally resistant to rust.

Grain Rusts. "Rust" is the name applied to the fungus which often occurs as yellowish brown or black spore masses on the leaves and stems of small grains, such as wheat and oats. These spore masses, or pustules, often are noticed about the time when the grain begins to head. At first the leaves and stems show yellowish spots, but gradually these change to a brownish color. This is due to the large number of rust-colored spore masses which project from the surfaces of the leaf and the stem. These so-called summer spores are soon scattered by the wind and insects to healthy neighboring plants, which likewise become diseased. Plants attacked in this manner are weakened, and a smaller yield of grain results, as there is less reserve food to store in the seeds.



Wheat stalks affected with rust. (After Freeman and Johnson.)

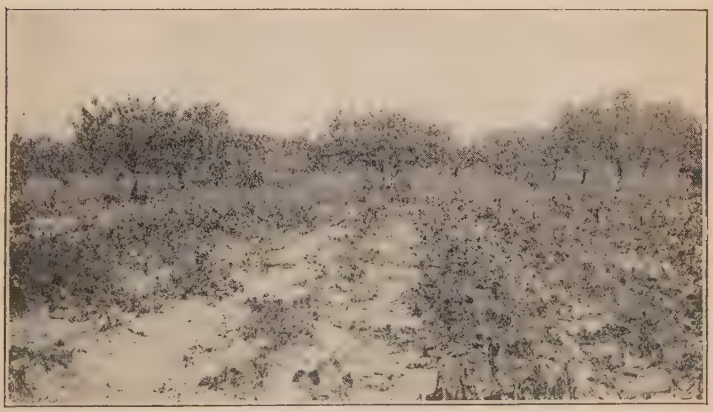
If one examines the grain, straw, and stubble at harvesting time, black pustules may be found. These are filled with the so-called winter spores. Both the summer and the winter spores help tide the disease over from year to year.

There are two kinds of rusts on wheat: the stem rust, which usually is found on the stem; the leaf rust, occurring

on the leaves. Both have a brown and a black spore stage. The stem rust is often called black rust, and is the one which does most damage to wheat. This rust also attacks barberries, and on them produces spores which again can infect wheat.

Rusts can not be entirely prevented. Neither spraying nor seed treatment is beneficial. The growing of varieties that are resistant to rusts is perhaps the only method of prevention.

Wilt of Cowpeas. Wilt of cowpeas is a disease which causes the leaves to drop and the stems to dry and become



Cowpeas on wilt-infected soil. Notice the healthy wilt-resistant variety on the right and the left, and the diseased non-resistant variety in the middle. (After Orton.)

covered with a pink fungus. This fungus may live in the soil for many years. A resistant variety of cowpeas has been grown, and whether the seed of this is planted on diseased soil or not, the seed sprouts and develops into a strong, healthy plant. Such plants can grow next to diseased ones in the same row and still remain healthy.

A disease-resistant variety of cabbage has likewise been

grown. Previously, all cabbages grown on soil which contained the disease-producing fungus would become diseased, and the crop would be a total loss. Patient, careful, and observant work on the part of the plant breeder brought forth a resistant variety.

QUESTIONS

1. What are some causes of plant disease? Which of these is most important?

2. What is a parasitic plant? Name two distinct groups of parasitic plants.

3. Give an example of a parasitic flowering plant. Discuss its economic importance.

4. Are bacteria plants or animals? Are all bacteria harmful? How do bacteria grow and reproduce?

5. What is a fungus? What is a saprophytic fungus? a parasitic fungus?

6. Describe a simple fungus. How does it grow and reproduce?

7. How may plant diseases be controlled? Can a plant be cured if it is once diseased?

8. How could you recognize pear blight if you saw it? What is the treatment for it?

9. If some one asked you how to ascertain the presence of early blight of potatoes as it occurs in the field, what would be your answer? What treatment would you advise?

10. Describe a disease which attacks the peach. What other fruits may be attacked by this disease, and what can be done to prevent it?

11. Name some diseases controlled by seed treatment. What are some common solutions used?

12. Describe the stinking smut of wheat. Name some other smut diseases that attack grain.

13. How would you recognize the potato scab? What treatment would you give the seed before planting it?

14. What do you understand by a plant's being resistant to disease? Of what value is this to the farmer?

15. Describe the wheat rust. Is this a plant disease easily controlled?

16. In replanting cowpeas in a field which formerly produced a crop affected by wilt, what kind would you plant? Why?

CHAPTER XXX

INSECTS ON THE FARM

Insects cause in Kansas an annual loss of not less than $40,000,000. This is more than three times the amount that is spent each year, not only on the education of the boys and girls and young men and women in the state, including those in the public schools, colleges, universities, and all private schools, but also on the upkeep of the buildings and the erection of new buildings.

The farmer needs no argument to convince him that insects are injurious to farm crops, because they feed on plants, stored products, and domestic animals. Even his own health and comfort are affected by these creatures. He may be surprised, however, to learn that the injuries caused by insects equal at least ten per cent of the value of all farm crops.

One must not think that all insects on the farm are harmful, for many of them are very useful. Some, such as the honeybee, contribute directly to the wealth of the state. Other insects contribute indirectly to the interests of mankind. For example, in carrying pollen from flower to flower and thus causing the flowers to fruit, insects are of great value to the farmer. Without the bumblebee and some other insects we should not be able to grow clover, because the plant could not produce clover seed. Again, there are many species of insects which are especially useful to man because they feed upon and within the bodies of other insects and thus are the most important factor in the natural control of harmful insects.

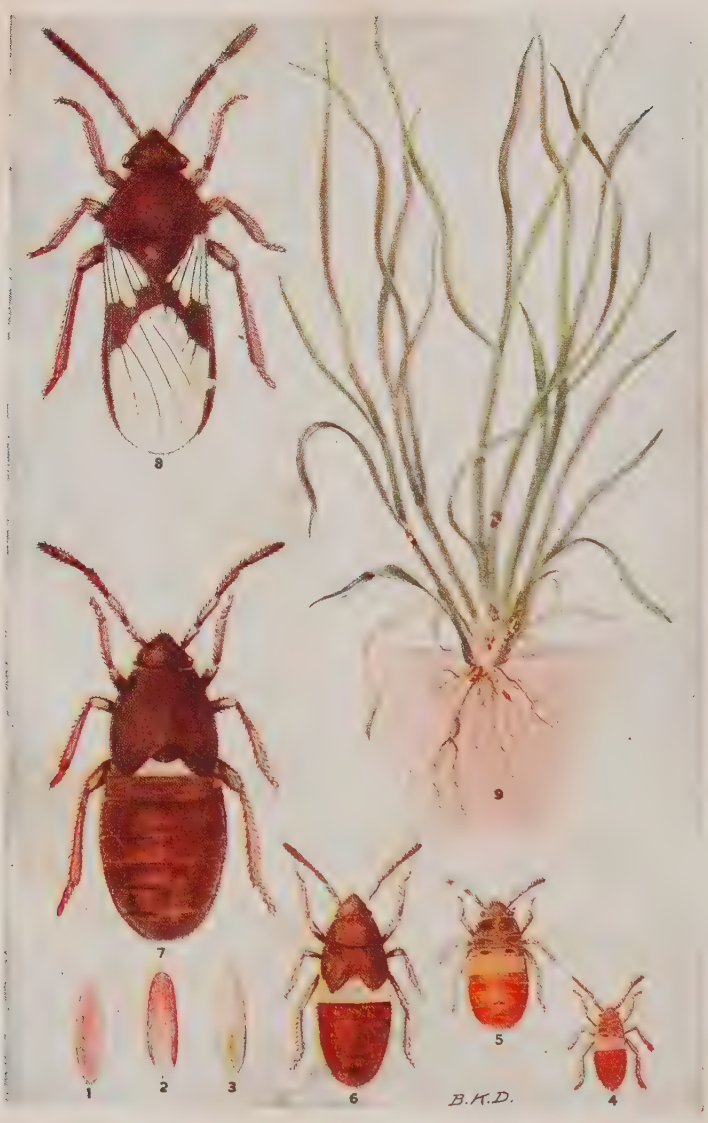
The Structure and Growth of Insects. All insects have three distinct regions of the body: first, the fore part,

or head; second, the middle part, or thorax; and third, the back part, or abdomen. They always have three pairs of legs, one pair of feelers called antennæ, and usually one or two pairs of wings. The legs and the wings are always attached to the thorax. Spiders, mites, ticks, scorpions, and sow bugs are not insects, but are related to them. They have four or more pairs of legs, and never have wings.

An insect does not have nostrils or any opening in its head through which it breathes. Instead there is a row of small openings, called spiracles, down each side of the body. Through these the air passes into air tubes, which branch and run to all parts of the body.

How an Insect Eats. A large number of insects eat their food by biting it, while, on the other hand, a great many take their food by sucking it up in a liquid form. If, for example, the mouth parts of a grasshopper are examined, it will be found that there is a distinct pair of jaws adapted for biting and chewing. Insects of this class bite off a portion of the leaf or plant and swallow it. If the head of a squash bug is examined, no jaws will be found. Instead there is a stout beak fitted for piercing and sucking. As this insect feeds, the beak is thrust down through the outer layer of the bark or leaf into the soft, juicy tissue beneath and the plant sap extracted.

It is necessary to know how insects take their food, for by knowing this we are able oftentimes to destroy them. Insects with biting mouth parts may be killed by a stomach poison, such as some suitable form of arsenic, placed upon the plant on which they are feeding. On the other hand, insects with sucking mouth parts can not be harmed by poisons on the surface of the leaves on which they feed, because they do not swallow any of the solid part of the plant. For this class of insects, sprays must be used which



THE CHINCH BUG

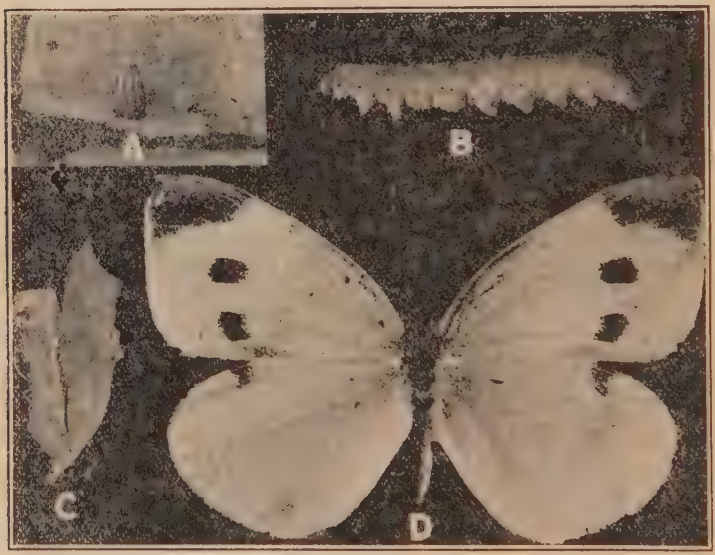
close the breathing pores of the insect or kill by caustic, or burning, action on the body of the insect.

Changes of Form in the Growth of Insects. Insects in their development from the egg to the adult undergo various changes. In some groups the changes are not complete, while in other groups they are so distinct that one stage does not resemble the one preceding or following it. For example, the egg of a grasshopper produces a creature which, except for the absence of wings, resembles the adult. This form, known as the nymph, is the growing stage. It sheds its skin, or molts, several times before it develops into a grown grasshopper. Such an insect passes through incomplete changes. Grasshoppers, chinch bugs, and dragon flies belong to this class.

The changes that take place in the life cycle of a grasshopper.

On the other hand, the egg of a moth hatches into a caterpillar, which is the active feeding stage, or the stage in which the insect does its serious injury to plants. The

caterpillar sheds its skin several times before it is fully grown. When full-grown it spins a casing of silk, known as a cocoon. In this protective case it transforms into the third stage, which is called a pupa. This is the inactive, or dormant, stage of its development, and in this stage it takes no food. The pupa does not resemble the



The changes that take place in the life cycle of a butterfly. *A*, egg in natural position; twelve times natural size. *B*, larva or caterpillar; *C*, pupa; *D*, adult; all 1½ times natural size.

caterpillar from which it came nor the moth into which it will later develop. In many cases the winter is passed in this stage, so that the pupal stage varies from a few days in summer to several months in winter. Finally the shell splits open and the moth emerges with wings which are soft and limp but which expand and harden in a few hours. The forms of the insect in these stages are so different that without experience one would not know

that they belonged to the same individual. Such an insect undergoes distinct or complete changes. Butterflies, beetles, house flies, bees and ants belong to the class. The growing stage of all insects that undergo the distinct changes is the larval stage, which is the caterpillar stage of the butterfly or moth, the maggot stage of the house fly, and the grub stage of the May beetle and of the honeybee.

FIELD, GARDEN, AND ORCHARD INSECTS

Before we can control insects, we must learn when and where they lay their eggs, when the eggs hatch, into what forms they develop, what the insects feed upon, where and at what stage they pass the winter, and how many generations are produced each year.

The Chinch Bug. The chinch bug is the most injurious insect, attacking growing corn, wheat, and oats. This insect passes the winter as an adult in a clump of grass, in a corn shock, or under almost any kind of rubbish. In regions where the clump-forming grasses are common, most of the bugs seek winter quarters in such places. They leave their winter quarters from March to May, and move to the fields of small grain. Here the females lay their eggs upon the roots or the leaf sheaths of the plants. These eggs hatch in from two to three weeks, and the young bugs feed on the small grain until it is ripe or harvested, when they migrate to the cornfields. Here they reach maturity, and then lay eggs on the corn plants or on the grasses and weeds in the cornfields. The eggs hatch in about two weeks, and the second brood feeds and matures in the cornfields. Generally all the bugs have reached maturity by the last of September. When the food gives out, or when cold weather sets in, the adults seek their winter quarters.

There are two times in the year when the chinch bug can be successfully controlled. The first is in the summer when the bugs migrate from the small grain to corn, and

the other is in the fall after the bugs have gone into winter quarters. In fighting the chinch bug in summer, barriers over which the bugs can not pass are set up. The kind of barrier used depends on the weather. In dry weather the barrier is a deep furrow extending around the infested field, and made just before harvest. The sides and bottom of the furrow are reduced to a fine dust by a heavy log dragged back and forth in the furrow. The furrow should be dragged every day during the migration, and the bugs should be burned in the furrow with a gasoline torch. In wet weather it is necessary to run a barrier of coal tar or No. 7 road oil around the infested field. Post holes are dug at intervals of twenty feet along the inside of this barrier, and the bugs, on being trapped in these holes, are destroyed by kerosene.

Winter destruction, in areas where clump-forming grasses are the principal cover, involves the thorough burning of these grasses in the fall. When bugs are found hibernating in corn shocks and under leaves and rubbish, clean culture should be practiced, and all these places should be cleaned up during the fall.

The Corn-ear Worm. The corn-ear worm is widely distributed in Kansas, and with the exception of the chinch bug is the most injurious insect attacking corn. In some years it does more damage than the chinch bug. It passes the winter as a pupa located in a cell from three to five inches beneath the surface of the ground in cornfields. The buff-colored moths emerge early in June, and deposit their eggs, principally on the upper surface of corn plants. The eggs hatch in a few days, and the worms feed in the curl of the corn for about seventeen days, when they reach full growth and enter the soil to pupate. The pupal stage lasts about two weeks, and the second brood of moths is out early

in July. The eggs of the second brood are deposited on the leaves and the early corn silks, and the worms feed in the curl, the tassel, or the ear. The third brood of moths is out about the middle of August, and the eggs are laid for the most part on the silks. It is this brood that does great damage, because practically all the worms feed within the ear.

Pupa of the corn-ear worm in its pupal cell, or burrow, in the soil. About natural size. (After Quaintance and Brues.)

The corn-ear worm is one of the most difficult of insect pests to control. It has been found that the fall plowing of the corn-fields destroys practically all the pupæ of this insect. It is possible to reduce the injury from twenty-five to forty per cent by early planting, so that the plants will have passed the silking stage before the insects emerge. One may protect sweet corn by keeping the silks dusted with powdered arsenate of lead from the time

Corn-ear worm moth with wings expanded. Natural size.

when they first appear until the corn is ready for market.

Corn-ear worm. Twice natural size.

The Hessian Fly. The Hessian fly, with the exception of the chinch bug, is the most injurious insect attacking wheat. In one recent season this insect caused a loss of fully twelve million bushels of wheat in Kansas. The adult flies, which emerge the last of August and during September, deposit their eggs on the leaves of the young wheat plants. The adults live but a few days, and during this time each female deposits between 150

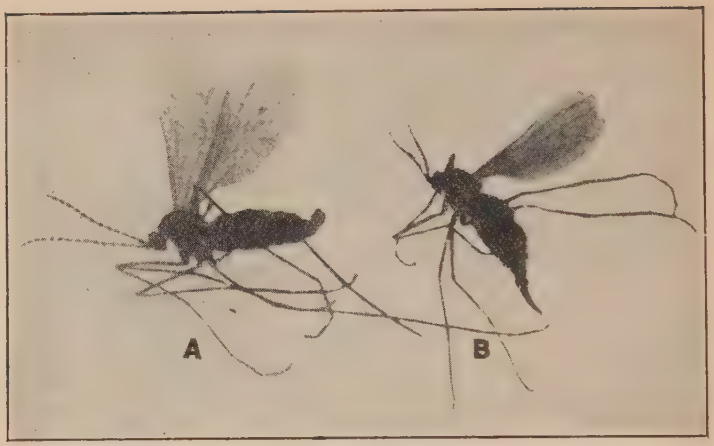
Corn silks, showing eggs of the corn-ear worm moth, slightly enlarged. In the upper left-hand corner are two eggs greatly enlarged.

and 300 eggs. The eggs hatch in from three to seven days, and the young maggots work their way down between the leaf sheath and the stem, to the crown of the

Corn, showing work of the corn-ear worm.

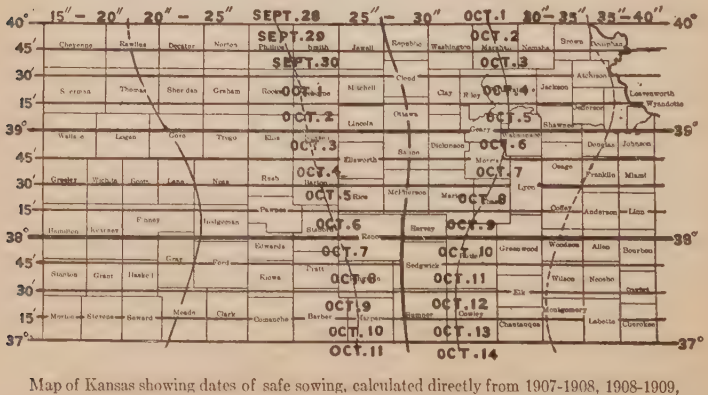
plant. Here they feed on the juices of the plant, causing it to turn yellow and to die. In about four weeks they reach their full growth and develop into brown objects called "flaxseeds." The winter is passed in this stage, and adult flies emerge in the spring as soon as the weather becomes warm. The eggs are laid on

The chinch bug: 1, egg just after it is laid; 2, egg just before it is ready to hatch; 3, egg shell after hatching; 4, young bug just after hatching; 5, young bug after first molt; 6, young bug after second molt; 7, young bug after third molt; 8, adult bug (all twelve times natural size); 9, wheat plant showing eggs and young bugs in natural position (natural size).



Male and female Hessian fly. *A*, male; *B*, female. Seven times natural size.

the leaves, and the maggots may be found working either at the crown of the plant or at one of the joints, generally the first or second. Here they weaken the stem and cause it to lop. These maggots reach maturity in about four weeks, or a short time before harvest. They transform to pupæ and remain in the stubble until



Map of Kansas showing dates of safe sowing, calculated directly from 1907-1908, 1908-1909, 1909-1910, 1910-1911, 1911-1912, and 1912-1913 experimental sowings.

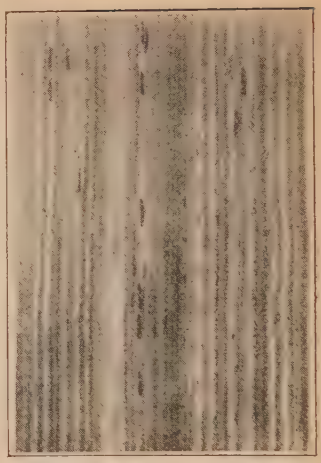
the latter part of August, at which time they emerge as adults.

The principal means of controlling the fly are thorough preparation of the seed bed, destruction of volunteer wheat, which serves to carry the fly over to the main crop, and late planting. Where wheat is to be planted on land which was infested with fly the previous year, the ground should be disked immediately after harvest in order to throw out and expose the flaxseeds to natural enemies, and should be plowed about six inches deep three or four weeks later. The field should then be harrowed and packed, and a dust mulch maintained until the time of planting. The sowing should be delayed two or three weeks after the usual date of planting.

Hessian fly puparia, or flaxseeds, in position between leaf sheath and stalk. Twice natural size.

Grasshoppers. Grasshoppers are among the most destructive of pests on the farms in the western half of the state, and almost every season they seriously injure crops. The young hoppers appear early in the summer. At this time they are small and have no wings, but otherwise resemble the adults. By about midsummer their wings are fully developed, and

during the latter part of the summer the females lay their eggs. The eggs are laid in pod-shaped masses about an inch below the surface of the ground, where they remain throughout the winter. With the coming of warm spring weather they hatch, and the young come to the surface, where they feed on growing crops and grasses. Pasture land, roadsides, undisturbed places, and alfalfa fields are favorable places for egg laying.



Hessian fly eggs in natural position on wheat blade. Eight times natural size.

One of the best times in which to attack the grasshoppers is in the egg stage. So far as possible, all suitable breeding places should be plowed in the late fall.

A cornfield being destroyed by grasshoppers.

Potato plant, showing Colorado potato beetle at work: *a*, beetle; *bb*, egg masses; *cc*, half-grown larvæ; *dd*, mature larvæ. Slightly enlarged. (After Chittenden.)

Alfalfa should be disked in the fall. Plowing and disking break up and turn out a large portion of the egg-packets, so that they are exposed to the weather and to natural enemies, such as parasitic and predaceous insects and birds.

After the eggs have hatched and the grasshoppers are destroying the crops, two methods of direct control are in general use—the distribution of a poisoned bran mash broadcast over the infested places, and the catching of

the grasshoppers in a mechanical device known as a hopperdozer. Poisoned bran mash, which has proved very effectual, consists of twenty pounds of bran, one pound of Paris green, two quarts of syrup, three oranges or lemons, and three and one-half gallons of water. This is made into a mash and scattered broadcast in such a manner as to cover five acres with the amount specified in the formula.

The Colorado Potato Beetle. The Colorado potato beetle, a native of the Rocky Mountain region, once satisfied with feeding upon various weeds, such as the Colorado

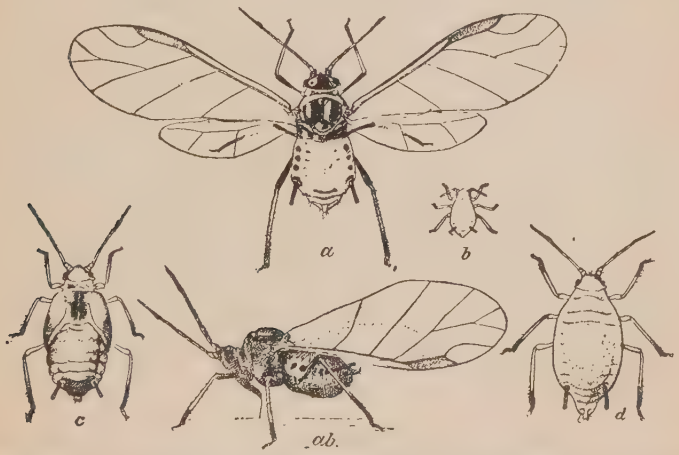
Cantaloupe leaves, showing curling caused by melon louse; lice on lower surfaces. Slightly reduced. (After Chittenden.)

thistle, is now found feeding on potato vines in practically every part of Kansas where potatoes are grown.

In the fall the adult beetles enter the ground and there hibernate until the warm days of spring, when the beetles come out from their winter quarters. As soon as the potato plants appear the female beetles begin laying their yellow eggs in masses on the under sides of the leaves. The female lays on an average about five hundred eggs. The adult beetles do considerable damage by eating the tender

plants. In about a week the eggs hatch, and the hungry larvæ devour the plants and increase in size very rapidly. In about three weeks they are full-grown, and enter the ground to pupate. In less than two weeks the adult beetles of the second generation appear. The Colorado potato beetle is two-brooded in Kansas.

Poisoning by means of Paris green has long been known to be effectual and practical. From one to two pounds of Paris green, with an equal amount of freshly slaked lime, to fifty gallons of water, applied as a spray, will kill the



Melon louse: *a*, winged female; *ab*, dark female (side view), sucking sap from leaf; *b*, young louse; *c*, last stage of immature louse; *d*, wingless female. All greatly enlarged. (After Chittenden.)

larvæ. For small areas the Paris green may be used dry if mixed with fifty times its weight of dry flour or air-slaked lime. This dust should be applied, either by means of a perforated can or by means of a powder gun, while the plants are still wet with dew.

The Melon Louse. The melon louse is a small, soft-bodied, greenish insect that causes the leaves of cucumber

and melon vines to curl, dry up, and die. One must not think that because these green lice are so small they are insignificant and will not injure vigorous plants. If they were only in small numbers, they would not be serious;

Cabbage butterfly resting on cabbage leaf. Natural size.

but, when millions upon millions of them are at work, and when the whole of the lower surface of each leaf is covered, the plants are soon killed.

During the early spring the lice suck the juice of various weeds, but with the growth of melons and cucumbers the winged forms make their way to the patches. They seek the under surfaces of the leaves and there begin to suck the sap and bear living young. If the grower is not watching his plants closely, the lice may get a start and do much damage before he knows that anything has happened.

As soon as the lice are discovered they should be thoroughly sprayed with a soapy spray. This spray, which is prepared by dissolving one pound of common laundry soap

Cabbage plant, showing work of the cabbage worm.

in six gallons of water, must be applied by means of a spraying apparatus in such a manner as actually to strike or wet every insect. When there are several plants to be sprayed, the common knapsack sprayer is best. The extension rod furnished with this sprayer should be replaced by one long enough to reach from the hand to the ground without one's stooping. The lower end should be turned up at an angle of from forty to ninety degrees and capped with a fine-holed nozzle. With this equipment the spray can be easily and thoroughly applied to the under sides of the leaves, where the lice congregate.

The Cabbage Butterfly. One of the best-known garden insects and the worst pest of the cabbage is the common cabbage worm, whose parent is the common white butterfly. The butterflies are observed hovering over cabbages and cauliflowers all through the summer. The small yellowish eggs are laid on the foliage and hatch in from four to eight days. The velvety green worms grow very

Apple branches. A, uninjured; B, injured with San Jose scale. (Slightly reduced.)

rapidly, eating large, irregular holes in the leaves of the plants and disfiguring the heads by deposits of excrement. The pupa is attached to the foliage by a strand of silk around the thorax. The pupa is first greenish and later light-brown in color. The whole life cycle in summer requires from three to five weeks. The winter is passed in

the pupal stage, the pupæ being attached to the old cabbage stumps and rubbish in the fields.

All rubbish on the field to which the pupæ are attached should be burned either in the fall or early in the spring.

The most effective means of control is spraying or dusting with Paris green or arsenate of lead. The arsenate of

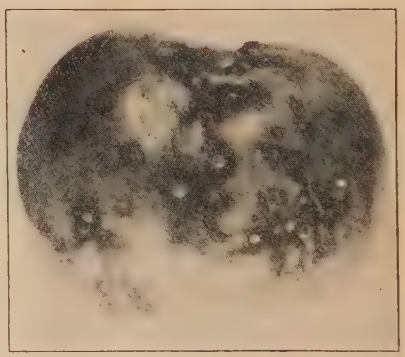
A portion of the incrusted apple branch in the preceding picture. Twenty-two times natural size.

lead should be used at the rate of two or three pounds to fifty gallons of water. Arsenicals can be used safely on cabbages until the heads are half formed. Since the leaves of cabbages are very smooth, it is advisable to add two or three pounds of resin soap, or "sticker," so that the spray will not run off the leaves.

The San Jose Scale. The San José scale, a serious pest of fruit trees and ornamental trees, is not generally distributed over Kansas, but is found in more than a dozen localities representing the principal fruit districts.

The San José scale is a flat, circular, scale-like object, bearing at its center a little point surrounded by a circular

groove. It lies flat upon the bark, and ranges from a tiny point to the size of an ordinary pinhead, depending on the degree of development. Beneath the protective scale-like covering is a lemon-yellow, soft-bodied object—the real insect. It passes the winter in a dormant state as a three-fourths grown insect lying flat on the bark. With the flow of sap in the spring, it begins to suck the sap from the tree or shrub and continues to grow. About the first of June it is fully grown, and then it begins to give birth to living young, and continues this at the rate of nine or ten a day for a period of six weeks. The young scales reach maturity and begin to bear living young in about one month from the date of their birth. There are four generations of the San José scale in one season, and it has been estimated that the progeny of a single female, if none were destroyed, would amount to about 3,216,000,000 individuals in a single year.



Apple infested with San Jose scale. Natural size.

San José scale may attack many kinds of trees, shrubs, and vines, but is primarily a pest of fruit trees, peach trees being most liable to serious infestation. Fruit trees and many shrubs can not be grown successfully where the scale has secured a foothold if no effective efforts are made to control it.

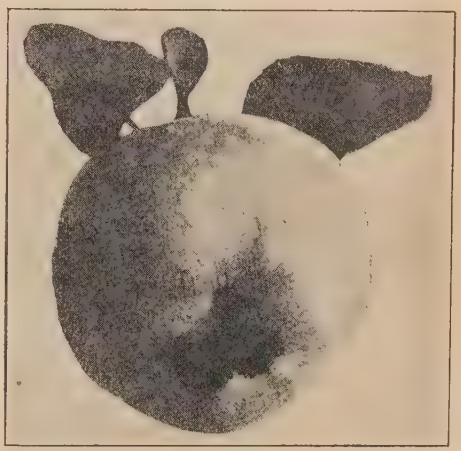
That San José scale can be controlled has been thoroughly demonstrated by thousands of fruit growers. Some of the general steps in this process are, first, to cut

and burn all hopelessly infested plants; second, to prune carefully all plants that can be saved, and burn the prunings; third, during the dormant condition to spray the trees thoroughly with lime-sulphur; fourth, to continue this treatment year after year so long as any trace of the scale can be detected.

Codling moth. The one with the wings expanded is two times natural size. The one resting on the apple is in the natural position and is natural size. (After Slingerland.)

The Codling Moth. The codling moth is the worst pest of the apple, and is present in Kansas wherever apples are grown.

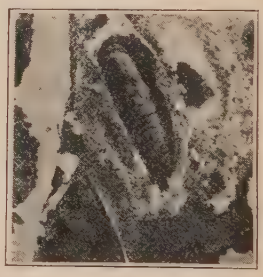
The moths appear early in the spring and lay their eggs on the leaves about two weeks after apples are in bloom. When the eggs hatch, the young larvæ feed for a short time on the foliage and then make their way to the nearest apples and bore into them, usually at



A wormy apple, showing the familiar mass of brown particles thrown out of the blossom end by the young larva. (After Slingerland.)

A codling moth larva. Two and one-half times natural size.

the blossom end. Until they are full-grown they feed about the cores of the apples. During June and July they emerge from the apples to pupate under the loose scales of the bark or in loose trash on the ground. In a short time the moths again appear, and start laying eggs for the second generation of larvæ. This time the greater number of eggs are desposited on the fruit, and the larvæ bore into the fruit through the side as well as at the blossom end. Here they feed until they are mature, and then eat their way out, travel to a suitable shelter, and spin their cocoons. They remain as larvæ in the cocoons, pupating the next spring.



Pupa of codling moth in cocoon on under side of loose bark. Twice natural size. (After Slingerland.)

The method of controlling the codling moth consists in spraying with lead arsenate at the rate of from two to three pounds to fifty gallons of water. The most important point is to apply the spray just after the blossoms fall, while the calyx cup is still open, and to direct the spray so that the poison will lodge in the blossom ends of the upturned apples. This should be followed in three weeks by a second spray when the worms are just hatching. For the second brood, a treatment should be applied about ten weeks after the first spraying.

Useful Insects. There are many species of insects, as the predaceous and the parasitic insects, which are useful because they prey upon injurious insects. Others are useful because they supply food, as does the honeybee. Still

others are very beneficial in carrying pollen from flower to flower, as do the wild bee and the honeybee.

Insects which attack other insects, devouring them bodily, tearing them to pieces, or sucking their life blood, are called predaceous. Good examples of these are lady-

Work of the codling moth larva in an apple. Natural size. (After Slingerland.)

birds, dragon flies, ground bettles, robber flies, lacewings, and tiger bettles.

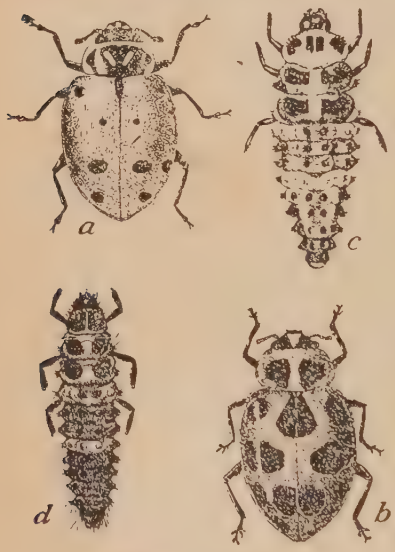
Parasitic insects differ from predaceous ones in that they spend all or a large part of their life cycle within the bodies of their victims, and thus destroy them. Such are ichneumon flies, braconids, chalcis flies, tachina flies, and bee flies.

Predaceous and parasitic insects are very great in number, both of individuals and of species. They are the most

destructive foes of insect life. Were it not for these insects, which feed upon injurious ones, the loss to crops would be much greater than it is, and in many cases it would be almost futile to attempt to check injurious insects.

PREVENTING AND CONTROLLING INSECT INJURIES

Clean Farming. Above everything else in preventing insect injuries, is cleanliness on the farm. This means clean culture, destruction of weeds, removal of crop remnants as soon as the crop is gathered, and burning the rubbish that encumbers the ground in winter. The one object of the farmer should be to destroy all hiding places that may be of service to the insects for winter quarters. This will go far toward freeing the farm, the orchard, and the garden from insects.



Two common species of ladybird beetles. *a* and *b*, adults; *c* and *d*, larvæ. Much enlarged. (After Chittenden.)

Fall Plowing and Disking. Many injurious insects, such as cutworms, corn-ear worms, wireworms, and white grubs, pass the winter as larvæ and pupæ in the soil, or hibernate around the roots of weeds and grasses. Breaking up the soil in the late fall and exposing these wintering forms to natural enemies and to the weather will greatly reduce the number. Disking alfalfa

in the fall is an effective method of controlling grasshoppers, army worms, and cutworms.

Selection of Place and Time of Planting. Too many times corn or other cereals are planted in places where they will be subjected to the attack of insects that are already present. Corn following grass or clover sod is likely to be attacked by cutworms and white grubs, and if planted in

The farmer's friend, the redtailed tachina fly: *a*, fly, natural size; *b*, fly, much enlarged; *c*, army worm on which the fly has laid eggs (natural size); *dd*, same, much enlarged. (After Slingerland.)

marshy tracts, is in danger of injury from wireworms and billbugs.

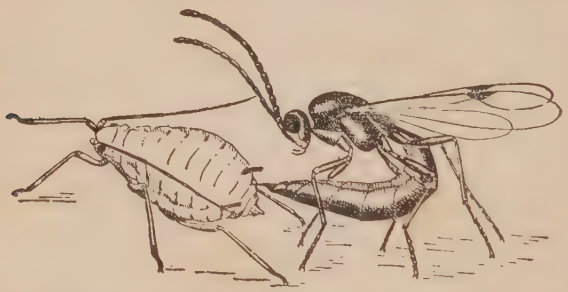
Planting at the proper time is a protection to many crops. Over a large area wheat sown after the first week in October is usually free from the attack of the Hessian fly. Early planting and good cultivation form one of the best means of enabling the farmer to avoid serious damage from the cotton boll weevil.

Crop Rotation. By a thorough system of crop rotation the increase of many insect pests may be checked or pre-

vented. Such a system will starve out an insect like the western corn-root worm, which is never injurious to the corn after the land has been in small grain. White grubs, cutworms, wireworms, plant lice, and the Hessian fly may be controlled in this manner.

The Soil. Thorough preparation of the soil induces rapid growth and thrifty, vigorous plants, which are not susceptible to injury from insects. It also disturbs and exposes the insects that are in the ground.

Stimulating the growth of the plant and keeping it in a thrifty, growing condition will make it better able to resist the attacks of insects. Plants in a weak condition, with no vitality, soon succumb to the attack of an insect enemy.



Green bug parasite in the act of depositing an egg in the body of the green bug, or grain aphis. Much enlarged. (After Webster.)

A good stand and healthy growth of plants lessen the danger of injurious insects. The field partly grown up with foreign weeds and grasses will produce pests that will later get on the planted crops.

Poultry and Other Birds. Chickens, guineas, ducks, turkeys, and geese are continually in search of insects that may be found upon low plants, in grasses, among weeds, and under rubbish and fallen leaves. Grasshoppers have been controlled by these fowls.

Inasmuch as birds depend very largely on insects for

food, they constitute one of the most valuable means of controlling insects. Were it not for the birds the loss from the depredations of insects would be very much greater. America is fortunate in having a large number of birds, and of these very few indeed are destructive to farm or orchard crops.

QUESTIONS

1. In what ways are insects injurious?

2. Name the parts of an insect's body. How do insects differ from spiders?

3. How do insects breathe? In what two ways do insects eat?

4. Describe in order the changes or stages in the life history of a grasshopper; of a moth. In what stages do insects grow? In what stages are they most injurious?

5. Why should the farmer know the life histories of injurious insects?

6. Give carefully the life history of the chinch bug, telling clearly how it spends the winter and how it migrates in summer. Give directions for controlling this pest.

7. Where are the eggs which produce the corn-ear worm deposited? How many generations occur in a summer? How may this insect be controlled?

8. Tell fully and specifically the life history of the Hessian fly. How and to what extent is this insect injurious? What methods are used to control it? Why are these means effective?

9. Where do grasshoppers deposit their eggs? When do grasshoppers become destructive? How may these pests be destroyed?

10. How do potato beetles spend the winter? How do they multiply during the summer? What measures are used to control them?

11. How does the melon louse get its food? Why is this louse so injurious to plants? How is it destroyed? Why are these measures necessary?

12. Give the life history of the cabbage worm. How may the gardener protect his cabbage from this insect?

13. Why is the San José scale considered so dangerous? How does it multiply and spread? What do orchardists use in their attempts to control this insect?

14. Give the life history of the codling moth. Give all the methods which should be used to protect the crop from this moth.

15. In what ways may insects be useful? Give examples.

16. Give the general measures of prevention and control that farmers may use in their struggle with insects. Explain why these measures are effective.

CHAPTER XXXI

SPRAYING

One of the most important but very recent general methods of controlling insect pests and fungous diseases consists in applying to the surfaces of plants, substances that will kill the insects and the spores of the fungi.

A substance that destroys insects is called an insecticide, while a compound that controls fungous diseases is called a fungicide.

Sprays. Sprays have been used by gardeners and florists for a long time. The old-time gardener used to distribute the liquid substances with a syringe and the powder substances with a bellows, and he called the processes "syringing" and "dusting." For very many years grape growers have dusted sulphur upon their vines to prevent mildew, and florists have killed plant lice with soapsuds and decoctions of tobacco.

About 1870 the Colorado potato beetle became very numerous and caused heavy losses to potato growers. A cheap poison was needed, and Paris green was found very effective in killing the insect. It was mixed with flour or lime and dusted upon the plants, or mixed with water and sprinkled on the plants from a watering pot or spattered on them with a whisk broom. Too much of this poison injured the tissue of the leaves, and the problem was presented of distributing the material evenly over the surface and in sufficient quantity to kill the insect without injuring the plant. Success in controlling the potato beetle suggested the use of sprays for other insects.

Bordeaux Mixture. The discovery of the value of copper as a fungicide was accidental. The downy mildew of the grape made its first appearance in France in the vineyards near Bordeaux, about 1878. The disease increased until, in 1882, great destruction resulted. The foliage of the vines dropped, which prevented the ripening of the grapes. It was noticed, however, along certain highways, that some vines retained their foliage in almost perfect condition. Vineyardists in these localities had suffered losses through the theft of their grapes by boys and travelers. It had been the custom to sprinkle verdigris, a poisonous compound of copper, upon the rows of vines near the road, to give the fruit the appearance of having been poisoned. Several years before the appearance of the mildew, verdigris had been replaced, for reasons of economy, by a mixture of milk of lime and copper sulphate. The vines thus treated were the ones which retained their foliage in 1882. As lime had been tried before without success, the beneficial action was ascribed to the copper. Two scientists, having made observations, experimented with copper, and established the value of the fungicide, which, in a modified form, is used very widely and is known as the Bordeaux mixture.

These were the beginnings of the modern methods of spraying. So great has been progress in recent years that to-day it is almost as common among orchardists to spray as it is to prune.

What Insecticides to Use. For biting insects, such as the potato beetle and the codling moth, some compound of arsenic is generally used. Arsenate of lead and Paris green are cheap and satisfactory forms. Paris green is speedier in action, and is less adhesive to the plants, but is more liable to injure the plant tissue than is arsenate

A power sprayer in the orchard. The spray material is forced upon the trees in a fine mist.

of lead. When cankerworms are very thick and must be destroyed quickly, a mixture of the two is frequently used. In such a case the spray is made up of two pounds of arsenate of lead and one-half pound of Paris green to fifty gallons of water.

Sucking insects are killed by the application of materials which destroy the body tissue of the insect, or which smother the insect by closing its breathing tubes. Of this type of insect the San José scale is perhaps the most notable example. It is most effectively controlled by coating the plants with a combination of lime and sulphur known as lime-sulphur wash.

There are many species of plant lice which cause very serious loss. The green melon louse and the brown plum louse are very common, and occasionally the apple aphid

is so numerous in early spring as seriously to injure the young fruit buds.

Spraying for Fungous Diseases. Fungous diseases which develop large numbers of spores are controlled in large measure by coating the surface of the plants liable to infection, with a thin film containing some substance which destroys the spore or the first growth that develops from it. The young spore is so much more delicate than the plant upon which it is growing that it is possible to use chemicals sufficiently strong to destroy the fungous tissue without injuring the plant.

Weather conditions must be observed carefully before applying these mixtures, as moist weather affects the copper solutions in such way as to cause "spray burn" and the lime-sulphur wash may be injurious in very dry, hot weather.

A number of copper compounds are used. The most common of these is copper sulphate, which is used alone dissolved in water, or in the combination with lime which, as has been stated, is called the Bordeaux mixture. This mixture leaves a light blue deposit upon the plant tissue. When this is particularly undesirable, as it is with flowers or ripening fruits, a colorless compound known as the ammoniacal solution of copper carbonate is used. This solution is prepared by dissolving three ounces of copper carbonate in one quart of ammonia (22° Baumé) and diluting this with twenty-five gallons of water.

Spraying Equipment. The spraying equipment necessary for outdoor work is a good pump with sufficient power to reduce the mixture to a very fine spray through a nozzle that distributes it evenly. The amount of power required varies with the operation and the mixture to be applied.

In applying fungicides and insecticides that are liable to injure the plant tissues, it is essential that the surface be covered with a very thin coating, and therefore high power is required.

For small orchards and garden work, a hand pump is sufficient. Hand pumps vary in capacity upward from the knapsack sprayer, which contains usually three or four gallons and is carried, suspended by shoulder straps, upon the back of the operator, and which is useful for small gardens and vineyards. For gardens of considerable area, a hand pump mounted on a barrel and transported on a cart or sled should be used. For larger plantations, a good outfit is a double-cylinder horizontal-stroke pump which has a capacity of 100 to 150 gallons an hour and is efficiently worked by two strong men. Large plantations should be equipped with one of the many efficient types of pump for which gasoline engines furnish power.

QUESTIONS

1. Why are sprays better than powders for protecting plants?
2. What kind of spray should you use for a biting insect? Why?
3. What kind of spray is used for sucking insects? Why?
4. How do sprays protect plants from fungous diseases? What spray is generally used for this purpose? Why must weather conditions be taken into account in using this spray?
5. What kinds of spray outfits are desirable for gardens or orchards of different sizes?

CHAPTER XXXII

ORCHARDING

For the sake, not only of economy, but also of better quality and greater variety of food, every farm home should produce as large a proportion as possible of the fruit and the vegetables consumed by the family.

The planter who has a large tract of land can usually afford to devote a considerable area to garden and fruit crops. He may use horse tools as much as possible in cultivating them, and be satisfied with a smaller yield than more intensive work would produce.

Planning for the orchard and the garden is a part of farm management important to the finances, the health, and the happiness of the occupants of the farm. The plans should be carefully made with the knowledge of how much space the various species will require as years go by, and with far-seeing vision in other respects also. It is all-important that every bit of soil be utilized, for neglected areas cause much trouble by growing weeds and by providing conditions under which insects multiply. For those crops which are not permanent the plan should include a scheme of rotation; for growing any species in one place for any considerable time is certain to result in the increase of insects and fungi, to lessen success and satisfaction, and often to cause dismal failure.

The owner of the land not only must consult his own preference as to crops, but must always consider whether his land is well adapted to the desired crops in soil, elevation, and general topography. The quantity and the

quality of orchard and garden products are determined by climate, soil, and care.

Climate. The factors of climate which seem to have most influence are temperature, moisture, sunshine, and wind. Any one of these factors may limit the success of a species. Not only the degree of temperature that may be expected, but the time of the year when it occurs and the variability of the weather conditions, have no small influence upon the success of fruit plantings. The tree which may not be injured by a January temperature of thirty degrees below zero might be seriously injured if that point were reached in November or March, and a frost may injure the blossoms of plants that would not be injured by very severe cold in midwinter. Sudden changes, rather than steady but extreme temperatures, injure fruit, especially if sudden drops below zero come in the fall or the spring, following mild weather.

Soil and Moisture. The factors of moisture and soil are closely connected, and frequently must be considered as one, for the condition of the soil in its ability to receive and retain water is fully as important as the amount of rainfall. Orchard crops require abundant moisture, but they root deeply, and if there is sufficient moisture in the subsoil they often succeed when cereal or vegetable crops suffer.

Subsoil. One of the most important factors in successful orcharding is the character of the subsoil. In investigating subsoil for orchard crops we must go deeper than for other crops, for we find extreme depths of great importance in the growth of tree fruits.

The point of first importance is that the soil be well drained, that it be of such depth and texture that it will readily receive the rainfall or the irrigation water, and that

no free water be held about the roots. "Fruit trees can not be healthy if they have wet feet," is one of the oldest of orchard proverbs.

Soils that require tile drainage are seldom good fruit soils, because these soils are usually underlain by a stratum that is not easily penetrated by water and is not favorable to deep penetration by roots.

Orchard Sites. Some of the best places for fruit growing do not have particularly rich surface soil, but possess a depth of soil and a moisture capacity that insure steady growth and abundant moisture. The hills of New England, the bluffs of the Missouri valley, and the sandy soil of the Arkansas valley are not so rich in some of the elements of plant food as are the black soils of the great valleys, but are better adapted to orchard crops because of the character of the subsoil, which absorbs moisture quickly and retains it well. The deep soils have frequently shown a high content of the mineral elements required by fruits. Trees root deeply, and the minerals are made more available as roots penetrate the soil, and as air and moisture more readily come into contact with the soil particles.

A soil analysis made by Professor C. C. Swanson shows that a very sandy soil in the Arkansas valley contains over two per cent of potassium. From a sample taken eight feet below the surface in the fruit-growing part of Doniphan county he learns that the soil contains, even at that depth, .024 per cent of nitrogen, .068 per cent of phosphorus, and 2.05 per cent of potassium.

Such soils are the most desirable for fruit plantations, since the supply of plant food is not easily exhausted, nor likely to be in excess, and since they retain moisture so well that even in very dry years the trees secure moisture sufficient for fair crops of fruit. Even where irrigation is

practicable, the subsoil is of great importance. The subsoil should retain water in such quantity that it will be unnecessary to apply water oftener than once in three to five weeks during the growing season, and that the winter demand for moisture will be abundantly supplied.

Almost any soil can be so prepared that trees and fruit plants may be successfully grown. A wet soil may be drained, a very dry soil may be irrigated, a poor soil may be enriched, and a shallow soil may be deepened by ditches and dynamite. Almost any expense might be justified in preparing a small area of soil for the trees and plants that are so large a part of a real home, but the commercial grower must compare his expenses and investments with those of his most favored competitor and decide whether or not he can go to such expense and hope for a profit.

Selecting Fruits for the Orchard. In considering the value of any fruit, whether for market, exhibition, or home consumption, we estimate it according to the relative importance of its different characters. The points given most consideration should be those which most certainly and uniformly affect the value of the fruit, and which indicate its quality and the probability of its best serving the purpose for which it was grown. It is probable that for different fruits, and perhaps for different localities, the weight given to a single character should vary somewhat.

The points of greatest importance in the selection of fruit in general are size, color, form, quality, and freedom from blemish. The points are not of equal value, and the weight given each varies somewhat with the different uses to which fruit is put.

The Meaning and Origin of Varieties. The general points of desirability having been fixed, the next question is, how to secure the maximum degree of excellence in each

of these characters. We see in the market or at the fair, fruits and vegetables that differ in many respects. We note that the labels designate them by name. Among the apples we note Jonathan, Grimes Golden, Ben Davis, Winesap, Maiden-blush, and many other varieties. What is a variety? The name of a plant consists of the name of the large group, or genus, and that of the smaller division of the group, or species. The genus *Prunus*, for example, includes the peach, the cherry, and several species of plums. The plum that has been introduced from Europe is *Prunus domestica*, the species name signifying "tame." The wild plum of the wood is *Prunus americana*, it being a native of America. There are many kinds of plums from Europe, varying in size, color, and form; and desirable ones have been increased and have been given names by which they are generally known; as, Yellow Egg and Blue Damson, which are now the names of what we designate as varieties. In all kinds of cultivated plants we have varieties. In cabbages we have Drumhead, Flathead, and Allhead; in strawberries, Senator Dunlap and Aroma; in grapes, Concord and Moore's Early; in onions, Prizetaker and Globe Danvers. The fruits or vegetables of one variety are products of plants which trace their ancestry to some particularly desirable parent plant. The original Jonathan apple tree, for example, was grown in Ulster county, New York, on the farm of Philip Rich, from seed of the old variety, Esopus Spitzenberg. It was so desirable that scions or twigs were taken from it and grafted upon trees which had less desirable fruit. As growers became acquainted with it, more trees were grafted, and from these others, so that all the thousands of Jonathan trees trace to the original tree. It was named in 1829 by Judge J. Buel, of Albany, in honor of his friend Jonathan

Hasbrouck, who had called his attention to the fruit. The origin of many valuable varieties is unknown. Varieties of vegetables and other plants grown from seed are kept pure by careful selection of the individuals which are to produce seed.

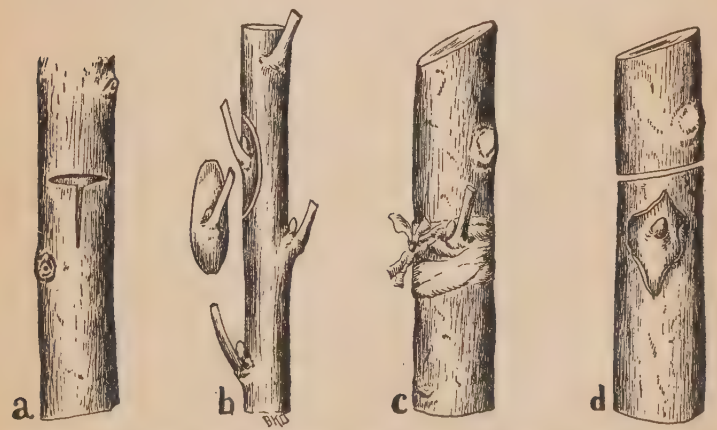
The Adaptability of Varieties. In striving to produce the best fruits and vegetables the matter of variety is of great importance. Varieties differ in hardiness, in productiveness, and in adaptability to varying climatic and soil conditions. Some varieties attain a high degree of success in many differing locations; others require peculiar environment for their successful development. The factors of environment which have the greatest influence on plant life are climate, soil, and neighbors, or the other plants and animals which are found in the locality. Particularly important in the list of neighbors are some members of the groups of plants known as fungi, and the insect forms of animal life. The grower must study each factor of environment in order to attain success in the production of fruit and vegetables.

Grafting: *a*, The scion; *b*, the stock; *c*, the graft.

Securing Trees of a Variety. In the early days of fruit growing it was the usual custom to plant the seeds of the fruit

desired, in a garden row, and then to transplant the young trees to the orchard; then, if the fruit proved inferior, to graft some more desirable kinds upon the branches. Since orcharding has become a business, men want to know just what fruit will be borne. They dig the seedling root, or stock, at the end of its first season's growth, store it in a cellar, and about midwinter graft upon it a scion of the desired variety and store it in sand in a cool cellar until spring. The graft, as the new union is called, is then set in the nursery row, where it is given every advantage of good soil and thorough cultivation until it is ready for the orchard, either as a one-year-old or as a two-year-old tree.

Budding to Secure Varieties. In growing peach, cherry, and plum trees, it is found that a better degree of success



Budding: *a*, The T-cut; *b*, the bud stick, and the bud removed; *c*, the bud in place and tied; *d*, the same ten days later, but with the tie removed.

can be secured by the process called budding. The seedling stock is grown in a nursery row, but, instead of digging it and grafting a scion upon it in the grafting cellar, the

nurseryman, in July or August, when the young stem is strong and vigorous and the bark separates readily from the wood tissue, cuts a single leaf bud from the desired variety and places its freshly cut surface in contact with the wood tissue of the seedling stock. A transverse cut is first made, next a cut down the stem; the bark is then separated with the knife blade, and the bud is gently pushed into the opening and tied with a cord, a strip of cloth, or a bit of raffia. In a week or ten days the buds are examined. If good work has been done, a large proportion of the buds will have "taken," as the nurseryman says, and the tie on each is cut, always on the side of the stem opposite the bud. The following spring the stem is cut off just above the bud, and the new tree is ready for the orchard in one year or in two, according to the size desired by the orchardist.

The Choice of Varieties for Kansas. The choice of varieties will be determined by the purpose for which the plantation is intended. If the planting is for home use primarily, it is a matter of personal preference; while if it is for market, the varieties should be those which rank high in the markets to be supplied. There are so many desirable varieties that it is largely a matter of choosing those that succeed best in the locality and are favored by the consumer. A list of varieties for any part of America would vary from the list for any other part. Some of the more important varieties grown in Kansas are given, somewhat in order of ripening, not in order of commercial importance.

Apples. Early Harvest, Cooper White, Maiden-blush, and Primate are all yellow or greenish yellow, with a slight blush on some specimens. The Wealthy is striped or nearly red; it is desirable in every way. Jonathan, a red,

and Grimes Golden, a yellow, are excelled by very few, and are known wherever apples are sold. The Delicious is a newer variety of considerable promise. Stayman and Black Twig are seedlings of Winesap, larger than the parent and of good quality and market favorites. Winesap, Ben Davis, and Missouri Pippin are old standard varieties that are well known in every apple market.

Cherries. The sour cherry is the only species grown extensively in Kansas and the Middle West generally. The best known varieties are Early Richmond, Montmorency, and English Morello.

Plums. Each species of plum has given us many varieties. In Kansas orchards we find, of the European species, the varieties Damson, Lombard, Greengage; of the Japanese species, Abundance and Burbank; of the various American species, Wild Goose, Weaver, Milton, and Forest Garden.

Peaches. Peaches vary in color of flesh and in adherence of the flesh to the stone. Free-stone varieties are most in favor. Some yellow-fleshed varieties are Triumph, Crawford, and Elberta. Some white-fleshed are Champion, Carmen, Belle of Georgia and Mamie Ross.

Age of Trees for Planting. Nurserymen offer either one-year-old or two-year-old trees for sale. The advantages of a one-year-old tree are: a better proportion of stem and root tissue; a lower cost of hauling and transportation; the fact that the tree may be more readily "headed," or formed to the ideal of the grower; the fact that less pruning is needed and less work is required in setting; the fact that only vigorous trees attain the desired measurements.

Many growers still prefer the two-year-old tree because it is larger, stronger, and less liable to be twisted out of shape by strong winds; because it requires less care in heading, as main branches have usually been fostered by

the nurseryman; and because it is the common size sold by most nurseries and consequently can be obtained with less trouble.

A careful man can grow good trees from either size, and it is more important that the young tree be vigorous, free from disease and insect pests, and true to its variety name, than that it be of any specified size or age.

A one-year-old apple tree is easily prepared for setting and may be headed as the orchardist desires. A two-year-old tree must be severely cut back to proportion the top to the shortened root system.

The Preparation of the Ground for Planting. In planning the use of the soil for at least one year before the date of planting, the grower should have the welfare of the tree in mind. The soil should be well and deeply plowed, the deeper the better, and thoroughly worked. The crops planted should be deep-rooted ones, and such as mature sufficiently early to allow early fall plowing. In localities where the soil is liable to injury by washing or blowing, the fall plowing should be done sufficiently early so that a cover crop of oats or cowpeas may be grown to protect the soil, or strips may be plowed for the tree rows, leaving corn stalks or stubble on the spaces between the

tree rows. In the Middle West, where there is sometimes a lack of moisture in late fall and winter, it is usually better to plant trees in the early spring than in the fall.

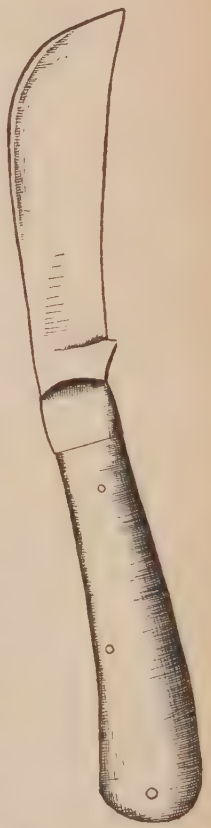
Ordering and Planting Trees. Trees should be ordered early and the buyer should be certain that he is dealing directly with his nursery or with its authorized agent and is not buying from some one who is "peddling trees." When the trees are received they should be unpacked at once, and the roots at once protected from sun and air. If for any reason the trees can not be set at once they should be "heeled in," or temporarily set in good, moist soil, care being taken that all the roots are in contact with the soil, with no air space that will allow drying out. Puddling the roots—dipping them in thin mud—is a good practice, but care must be taken that the soil used is sandy or loamy and not a sticky clay.

For planting the trees, holes should be dug large enough to allow the roots to be well spread, and the tree should be set a little deeper than it stood in the nursery. Trees may be well and quickly planted by opening a furrow with a lister or a double plow. The furrows should not be opened much in advance of the planter, if the air is dry, and should be filled immediately after the tree is set. Two-year-old trees should be pruned back considerably, but enough good buds should be left to insure thrifty tops. One-year-old trees are usually headed back to eighteen or twenty-four inches.

Caring for Young Trees. After the tree is set we should remember that it is an investment that has a high profit-producing power. If we expect to realize a profit from the investment we must give it careful and continual attention. We must have a strong, well-made plant, and the little tree must be given every opportunity it can use. It

must be given the exclusive use of all the soil it can occupy. That soil must contain all the materials it can utilize, and we must allow it considerable surplus energy in its early years.

It would be a serious mistake to try during the first few years to restrict the growth of the tree to the few branches that will form the structure which is to produce the fruit. Let it grow as fast as it can, but keep in mind the form that it is to attain as it gets older. The tree must grow larger, and the material for this growth is manufactured by leaves; therefore we must have a large number of leaves if much wood is to be formed. But the grower must have in mind the form of tree best suited to produce fruit, and so prune the tree as to cause it gradually to grow to this form.

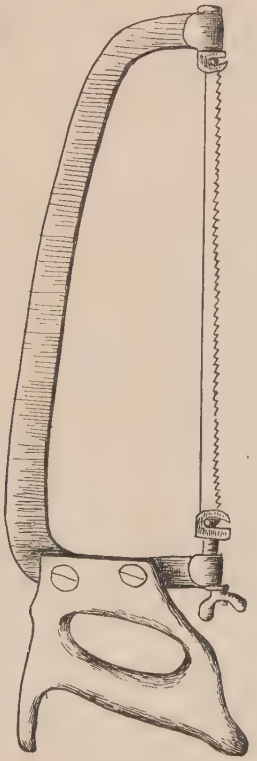


For young trees a strong knife is the best pruning tool.

Pruning. Whatever the object sought, pruning should be carefully and thoughtfully done. Tools should be clean and sharp, and the work should be done in a workmanlike manner. The workman should clearly understand the object in view and the reason for performing each operation. When it is a question of the removal of one of several branches, he should have a reason for the decision and not refer his choice to chance. In addition to pruning for growth and formation and for maturity and productiveness, protective pruning is sometimes required to remove

diseased tissues and prevent the spread of disease. In such cases the tools should be thoroughly cleaned and sterilized, and the wound should be made in sound wood and then carefully painted. A paint composed of pure white lead and linseed oil is satisfactory.

When branches are cut off the wound should be close to the limb from which it originates, and made smooth and even. If the limb is heavy and there is danger of splitting into the permanent tissues, a cut on each side should be made to prevent the tearing of the bark and young wood.



A good saw for larger branches.

A curved-blade saw, useful for light work.

Pruning Tools. There are on the market many kinds of pruning tools, concerning which men differ in their opinions. A good workman can do good work with most of them. Two very popular saws are the steel-frame saw with blades with different sizes of teeth, and the

curved-blade saw, which for light work is favored by many workmen. Heavy clippers are satisfactory for many special purposes. For pruning vines and bushes a pair of grape pruning shears is indispensable.

Pruning to Secure Fruit. To secure fruit we need flowers, and we must study the formation of flower buds if we would secure flowers. Plants vary much in what the grower calls the fruit habit. The matter of securing fruit buds is the achievement the fruit grower has always in mind. The apple, the pear, the cherry, and most varieties of plums bear their fruit on spurs, or very short lateral branches. To obtain these spurs is to obtain the means to the end. These spurs are often crooked and irregular, particularly upon old trees, and ignorant people sometimes clip them off in an effort to make a clean, handsome tree. These spurs usually bear fruit in alternate years; in the year in which the fruit is borne, a leaf bud is produced in addition. The year following, the leaf bud develops a cluster

An apple spur in July, 1914: *a*, fruit buds for the crop of 1915; *b*, the crop of 1914; *c*, scar where the 1913 stem was produced; *d*, the unproductive wood of 1912; *e*, scar of the apple borne in 1911; *f*, location of the fruit borne in 1910.

of leaves and a fruit bud for the next year's fruit. The spur should be cherished as the vital part of the tree. The spur is often injured by careless fruit pickers. The spurs of the cherry are particularly liable to injury through the tearing of the bark when the stem of the fruit is removed. The spur is in this way often killed. The cherry and the plum are usually less vigorous in growth than the pear and the apple, but are much more regular in their fruit habits.

Pruning the Peach. On the peach tree flower buds are so far developed in the fall that we can easily recognize them by their full, rounded appearance. We look for them only on the new wood of the season's growth. These buds are more easily injured than are less well developed buds. In localities having a variable climate there are fewer crops of peaches than of fruits the buds of which are not so well developed in the fall. The peach develops such a large number of buds that it can not furnish food for them all. We must cut back the branches and thin the fruit if we would secure the size, the color, and the quality that we desire. Whenever the fruit buds are killed by winter cold or spring frost the tree should be pruned back severely, in order that the new growth upon which the buds will form may be kept low enough to make thinning and picking easier.

Summer Pruning. We do not want a tree to bear until it has sufficient size and strength to produce a profitable crop, but we do want it to bear as soon and as heavily as it can without lessening its vitality and shortening its life. A tree that is making a very vigorous and heavy growth of new wood is not likely to form fruit spurs. If in the spring the new growth is very strong and the new shoots make a very strong growth, the lateral buds along the

older stem do not develop at all or form but a leaf or two that soon fall. To develop these lateral buds, in early summer we cut back and thin out the new growth. This

Trees must be so pruned as to admit light to the center, in order that the fruit spurs may be well developed and produce strong, healthy flowers.

makes it possible for the lateral buds to absorb more food from the stem and gives the lateral bud more light, enabling the leaves from the lateral bud to prepare more food and inducing spur growth.

The richer the soil and the more favorable the conditions for the growth of new wood, the greater the necessity for systematic summer pruning. Very dry weather in spring and early summer sometimes gives the conditions required for the formation of spurs and fruit buds. In localities where all or most of the soil moisture is secured by irrigation the conditions favorable to bud formation may be more certainly secured and the trees come into bearing

at an earlier age than in places where the rainfall is likely to be heavy in the spring and summer months.

While conditions vary somewhat, the general requirements in growing fruit trees are:

First, to secure a strong tree with a form that will carry a heavy weight; to admit sufficient light to favor bud

A well-shaped Winesap tree that at seventeen years of age produced twenty bushels of apples

development; and to give color to fruit by thorough cultivation and winter pruning.

Second, after the tree has sufficient size to carry a crop, to induce the formation of fruit buds by cutting back and thinning out the new growth, giving more light and food for spur formation. If summer pruning should be followed by heavy rains, a new growth might be induced which would defeat the purpose of the pruning. This possibility should be anticipated by ceasing to cultivate and sowing a

cover crop, which will use part of the water and available plant food that the tree might otherwise get.

Cropping and Cultivating the Young Orchard. The young tree in its early growth should have every opportunity to make a rapid growth, but it would be poor farming to devote a square rod to the tree when three square yards are sufficient for its growth for a year or two. Therefore other crops may be grown between the trees during the first few years. Small grains and sown fodder crops should be avoided. It is difficult to harvest small grain among trees, and it is much better to use crops that require cultivation.

In exposed locations corn is an excellent crop if the grower, remembering that the corn plant is greedy, will therefore give the tree sufficient area. Strawberries are often grown between the rows without injury to the trees. The black raspberry is the best of the bush fruits for an orchard crop. It is not so rank in growth, and may be more easily killed by plowing than the other brambles. Melons, squashes, and pumpkins are good crops for orchards. Potatoes, tomatoes, and in fact any vegetable crop, may be grown if the welfare of the tree is always given first consideration.

In plowing and cultivating care must be taken to keep the surface level. Ridging the tree row is a common orchard error; for, as the trees increase in size, it becomes more and more difficult to cultivate near the tree, the ridge becomes hard, and water is drained away, tending to form a waterway and often causing ditches, waste of soil, and inconvenience. At the first indication of ditch formation, some brush, straw, or other material should be used to spread the water and stop the washing.

As the trees increase in size and the area available for intercropping grows less, the character of the soil and the

A reversible cutaway disk enables the orchardist to cultivate well under the spreading trees.

general condition of the trees must be considered in planning for the welfare of the orchard. On hilly land, where washing is a problem, a cover crop is a necessity. A cover crop is one grown in the orchard, left over winter, and plowed under in the spring. It is usually a quick-growing crop, planted late in the summer. On some soils, particularly in localities of abundant rainfall, crimson clover gives good results. An occasional cultivation with disk or shovel tools may be given, and the clover will form a mulch that will add to the soil fertility. Careful growers who are conscientious in returning the fertility to the orchard in the form of manure may find profit in using the clover as a hay, but, after the orchard is in bearing, there are few exceptions to the rule that the trees need all the food and moisture that can be made available. A clover cover in some regions is followed by a stand of blue grass, which, forming a thick, close sod, is unfavorable to the orchard and should be prevented.

On sandy soils of the river valleys a combination of early cultivation and late cover crop is advisable. In some cases very good orchard conditions are maintained by occasional disking and frequent mowing.

In regions where the rainfall is liable to be deficient the best treatment comprises clean cultivation and an occasional application of barnyard manure to maintain the texture and fertility of the soil.

Fertilizers. The principles of plant nutrition apply to fruit growing. Before applying fertilizers to any crop in any locality, one should ascertain by observation and experiment what substances will give best results. Fruits need soils strong in potash and phosphorus. Occasionally the supply of nitrogen is too low for the best results. Clover or cowpeas as a cover crop will usually supply sufficient nitrogen. In the Middle West, where manure

may be obtained from feed lots and stock yards, the needed element may be supplied in this way as cheaply as with the mineral substances, while at the same time humus is added to the soil.

General Care. In addition to proper preparation of the soil and cultivation to conserve moisture, to keep down

A spring-tooth harrow is a good implement for maintaining the surface mulch, and, with the extension wings, covers a large area in a short time.

weeds and to maintain soil fertility, the fruit grower must work to prevent loss from injurious insects and plant diseases. As soon as the presence of an insect is noted, measures should be taken for its control. Insects increase in numbers so rapidly that a single season's neglect may ruin a plantation.

The two methods of preventing injury are the destruction of infected plants, or such parts of plants as may be necessary, and spraying. If a plant is badly infected with an insect or disease, the grower must ascertain at once if the trouble can be controlled without destroying the plant. If it can, he must do the necessary work at once. A few hours spent in removing the infected bushes in a black-

berry patch saved an area that produced profitable crops for several years. The orchardist who does not spray his trees when a pest is first noticed may in a single season lose a hundred times the cost of the spray.

The Grape. There are many species of the grape genus, *Vitis*, varying from the large one of Europe to the small

One man on the ground and one in the tower, with two hundred pounds pressure at the pump, make an effective combination for fighting the codling moth.

wild grape found in all parts of the West. Many varieties have been developed from these species.

The American varieties withstand more cold and are more resistant to diseases and insects than are those of Europe. In every part of the United States except the northernmost some varieties may be grown. From some varieties that bear small bunches and berries of small size a very fine quality of juice and jelly is obtainable.

Grapes are propagated from cuttings, and grow so

readily that good vines may be secured cheaply. The usual method is to make the cuttings in the fall and store them in a cool cellar or bury them until spring, when they are set in a nursery row and kept well-cultivated and free from weeds. They may be set in the vineyard one or two years later. When set in the vineyard they should be pruned back to one or two buds, and one year later again cut back, in order that they may be vigorous. After the second season they usually produce abundantly.

On rich soil grapes should be set farther apart than on thin or poor soil, and should be allowed to set more fruit. On soils of fair quality, eight feet apart each way is a good distance.

The American grapes grow best on a trellis. Almost any form of trellis is satisfactory if the vine is pruned carefully. In cool or damp climates the trellises are made high, to allow a good circulation of air and to ripen the fruit a little earlier. In dry, hot regions the trellis may well be lower, to protect the fruit from sun and wind. The pruning may be done at any time after the leaves fall and before the buds begin to swell in the spring. The grape bears its fruit on new shoots which develop from the preceding year's growth. We prune the vines rather severely, leaving comparatively few of the buds, as we know that the quality and the size of the fruit in a fair crop will give it more value than would be possessed by a larger weight of inferior fruit.

The varieties of grape best known in Kansas are Concord, Moore's Early, Worden, Catawba, Diamond, and Elvira. Some hybrids, secured from the American and European species, are superior to the American in flavor and quality, but are injured by a degree of cold which does not injure the American vines. Brighton, Agawam, and Goethe may be grown if the grower protects them through

the winter by laying down the canes and covering them with earth. For hot, dry localities some varieties originated by R. V. Munson, of Texas, by crossing the post-oak grapes with other varieties, are best. Among them are Fern Munson, Headlight and Xylenta.

Small Fruits. Small fruits deserve all their popularity; for they are generally successful, come into bearing soon after planting, and are not difficult to grow.

The Strawberry. The strawberry is the first fruit of our season, generally ripening in Kansas in the last part of May and the first part of June. It usually gives large returns for cultivation and care. Strawberries are propagated from stolons, or runners, a single plant in the course of a season producing a number of new plants.

A single strawberry plant set in the spring will produce, by means of stolons, a large number of plants during the following season.

Good garden soil is best for strawberries. Corn land that has been heavily manured and put into condition to grow a heavy crop of corn will grow good berries. Freshly broken sod or freshly manured soil should be avoided, as the white grub, the larva of the insect called the May beetle or the June bug, infests such soil and seems particularly fond of the roots of the strawberry plant.

Commercial growers of the Middle West usually set

the plants in the spring in rows four or five feet apart, and twelve to eighteen inches apart in the row. Care must be taken not to set a plant so deeply in the ground that the crown or the buds may be covered by heavy rains. The blossom buds which appear on the new plant should be removed as soon as they appear, or the plant may be exhausted in producing a few berries. The plant will produce stolons, and they should be so placed about the plant that each will have sufficient space for development. Varieties differ in plant-making power, some producing but few plants, while others produce more new plants than the ground can support.

Rows made up of the latter varieties usually become thickly set by fall. This is called the matted-row system.

Much better fruit is secured by the hill system, in which no runners are allowed to form. the plant developing all its strength in fruit buds.

The single-hedge row, in which each plant is allowed to produce two runners, and the double-hedge row, in which each plant produces four new plants, are systems that are increasing in favor, for the berries are larger and better developed than where grown in a matted row. In most seasons thorough cultivation will conserve sufficient moisture for a strawberry crop, but in dry soils and particularly trying seasons irrigation should be practiced if possible.

After the fruit is picked the plants should be severely thinned and the ground put into good condition. A mulch of cleanly threshed straw or coarse hay should be applied after freezing has checked the growth, and should remain until spring. Delay in removing the mulch may cause the plants to bleach, which should be avoided.

Some varieties of the strawberry have imperfect blossoms, which do not produce pollen, and companion varie-

ties which are perfect-flowered must be planted near them. The imperfect varieties have usually produced better or more even crops than the perfect-flowered. Warfield, Haverland, Bubach, and Sample are popular varieties having imperfect flowers. Senator Dunlap, Aroma, Brandywine, Chesapeake, Splendid, and Bederwood are perfect-flowered and generally profitable.

Bush Fruits. Blackberries, raspberries, and gooseberries should find a place in most gardens. These fruits will do well on soils varying from a sandy loam to clay, but, whatever the soil, it must be in good condition as to texture and plant food.

The red raspberry does not withstand dry weather and low temperature so well as do the others. Thorough cultivation and care are important. Early spring setting is best. A light crop may be expected one year after setting and a full crop the second year.

The black raspberry propagates by means of the tips of the canes, which touch the soil and take root. The gooseberry propagates from layers, the others from suckers. In all except the gooseberry the berries are borne on canes of the preceding year. The fruit of the gooseberry is borne on older wood

Pruning the gooseberry consists in removing the wood which is so old as to be useless. Pruning the others consists in removing the canes which have fruited. This may usually be done more easily after the ground is frozen. The new canes are also clipped back just before the berries are picked. This facilitates picking and induces a growth of laterals. Thorough cultivation will decrease suckering and will keep the stand thin.

In Kansas the most extensively grown varieties of red raspberry are Miller's Red, Cuthbert, and London; of black raspberry, Kansas and Cumberland; of blackberry,

Early Harvest, Snyder, Mercereau, Erie, and Ward; and of gooseberry, Downing.

QUESTIONS

1. Name three factors that determine the success of orchards.
2. What is the best type of subsoil for an orchard?
3. What is a variety? How are varieties secured? What factors are to be considered in selecting varieties?
4. What are the best varieties for Kansas: (*a*) of apples; (*b*) of cherries; (*c*) of plums; and (*d*) of peaches?
5. Describe budding. When should it be performed?
6. State the advantages of planting one-year-old trees; two-year-old trees.
7. Name some necessary pruning tools. How should the peach tree be pruned? What are the advantages of summer pruning?
8. When may cropping be an advisable practice in the orchard?
9. What varieties of grapes are adapted to Kansas conditions?
10. Describe the culture of the strawberry.
11. How are bush fruits pruned?

CHAPTER XXXIII

THE VEGETABLE GARDEN

A vegetable garden may be looked upon as a pleasure and as a necessity. Small areas of land yield great varieties of desirable vegetables, and so make the diet not only more economical, but more pleasing, more healthful, and less monotonous. A better quality of vegetables can be secured from the home garden than one can buy under

Vegetables that are washed clean and attractively prepared have a better chance in the market than has the product of the careless grower.

ordinary conditions. The garden furnishes interest and occupation for every member of the family and yields satisfaction and profit in direct proportion to the thought and care expended on it.

The Site for the Garden. If possible, the garden should be near the house, so as to be easily accessible. It should

be protected from chickens and other stock, and, where possible, should be near enough to the water supply so that it may be irrigated when necessary. The soil should be the best available, either naturally or through improvement. There should be slope enough to drain the garden well, but not enough to make it wash. Ordinarily, it is desirable that the garden be relatively long and narrow, so that vegetables may be planted in long rows and cultivated with tools rather than by hand.

The Care of the Garden. More gardens fail because of improper preparation of the soil than for any other cause. Often no garden preparations are made until the birds and the flowers suggest that spring has come, and then a small patch is hastily spaded or plowed, and planted. Such practice usually results in failure. The best preparation for a garden is to plow in the fall and to use large quantities of well-rotted manure. The manure should be applied in considerable quantities in the fall and plowed under. If the garden is new and the soil poor it will pay to do a great deal of work to get the manure and the soil well mixed.

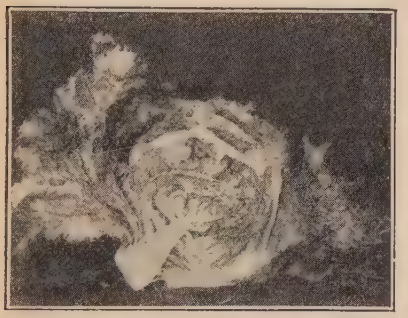
Fall plowing aërates the soil and helps to release plant food, helps the soil to retain moisture, destroys insects by exposing them to frost, and usually warms earlier in the spring than unplowed land. If there is considerable slope, fall plowing should be done across the slope to prevent washing. Where the soil blows, the garden may be covered with coarse manure after the fall plowing and the blowing prevented. In the spring all the coarse manure should be removed. Only fine manure should be applied to a garden and left, for coarse manure interferes with the plants and with working the garden. For the best results, both plowing and liberal manuring should be practiced year after year. Quality and kind of manure should vary somewhat

with the plants which are to be grown in different parts of the garden. Old, leached manure will not force the growth of stems so rapidly as will recently decomposed manure. This should be kept in mind in preparing the soil and planning the garden.

Planning the Garden. The garden should be planned to enable one to care for it with the least loss of time and labor. Long, narrow gardens permit all the vegetables to be planted in rows and cultivated with wheel tools. Small beds are wasteful of land and require a great deal of extra labor. The soil should be occupied all the time. This means that we should plan to have a second crop follow the first early-maturing crop, and that the early-maturing crops should be planted with this in view. The gardener should also plan to place the crops according to the way the manuring has been done. As a rule, crops which are grown for leaves or stems are planted on recently manured soil. Lettuce, spinach, cabbage, cauliflower, and chard are examples of such crops. With these we may class those plants, such as corn, squash, and melons, which produce a large amount of stalk or stem before producing the seed. Plants grown for the fruit or the seed parts, and those which store reserve supplies of food in roots and tubers, succeed better on soil which has not been so recently or richly manured. Examples of these crops are tomatoes, egg plants, peas and beans, beets, carrots, parsnips, potatoes, and sweet potatoes. Careful planning of the garden means careful preparation, careful arrangement of the plants in the garden, and planting for a succession of crops on the same land during the year and during succeeding years.

Selecting Garden Crops. For the home garden, the preferences of the family will determine what shall be

grown. Market gardeners must be ruled by the market demands. The market gardener must also select varieties which will stand handling and transportation well.



Good lettuce must be quickly grown, so that the inner leaves may be closely folded, white. and crisp.

In planning the home garden the amount of space given to any one crop will depend upon the quantity needed and upon whether or not an excess may be preserved for winter use. Lettuce and radishes must be used at once, while an excess of beets and beans may be canned or pickled for future use.

Garden crops which require careful attention at a definite time should not be grown if the work of a large farm is likely to interfere with proper care of them. Under such conditions one should select staple garden crops and standard hardy varieties, rather than specialties or fancy crops. Where plenty of time can be given, however, one may well grow special crops which require special attention, and be repaid both in pleasure and in profit.

The dates for planting the different garden crops vary somewhat, but the relative time for planting the different species is usually fairly constant. The exact date of planting is a matter of judgment or guesswork, but, while the early planting may sometimes fail, the demand for early products is such that it is worth while to take some chances with the weather.

Lettuce, radishes, turnips, beets, onions, spinach, and smooth-seeded peas are hardy, and may be sown as soon as the soil may be worked.

Beans and wrinkled peas and corn may be planted as soon as the soil begins to warm well, and carrots, parsnips, and salsify for winter use may be planted at this time if they have not been planted with the early vegetables.

Hotbeds. The purpose of the hotbed is either to start or to grow vegetables earlier in the spring than they could otherwise be grown. Sometimes lettuce and other crops are allowed to grow in the hotbed until they are large enough to use. Usually, however, plants are started in the hotbed and then transplanted.

The hotbed should be placed on the south side of a building or other good windbreak, and care should be taken to have good drainage. The north side should be five or six inches higher than the south side, so that the glass covering may incline toward the sun. The sides may well be from twelve to fifteen inches above the soil on the north side, and from seven to nine inches on the front. A convenient size of sash is three by six feet. The bed should then be six feet wide north and south, and may be as many times three feet long as desired. Placing the sash thus north and south gives more sunlight. For starting sweet potatoes many prefer to cover the bed with muslin. The sash should fit tight, and in very cold weather should be covered with straw matting or wooden shutters.

Building Hotbeds. A hotbed frame is sometimes set upon a pile of fermenting manure, in which case the pile should extend for about a foot around the edges of the frame, to hold the heat. It is best, however, to have a pit about two feet deep. If the bed is to be permanent, the pit may be a foot wider than the frame and be walled with stone or brick. Upon the bottom of the pit place a layer, two or three inches deep, of straw, leaves, or any other coarse material. Then place a layer of manure eighteen

to twenty-four inches deep, a thin layer of leaf mold or other material above this, and lastly a layer of four to six inches of good, rich loam, in which the plants are to be grown.

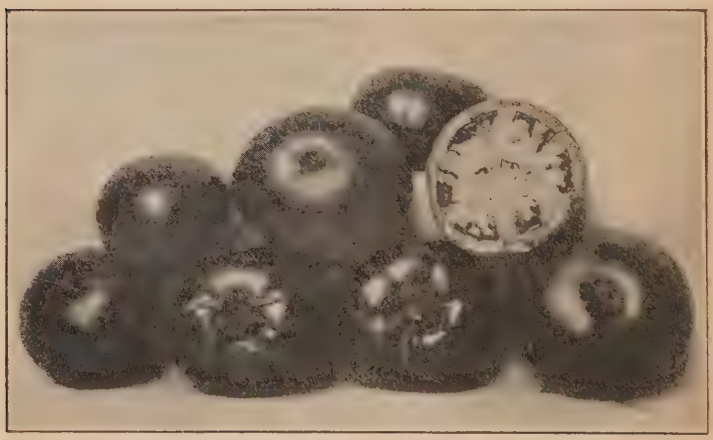
Preparing Manure for Hotbeds. The heat for hotbeds is commonly supplied by the fermentation of horse manure. Fresh manure from highly fed horses is the best. It should be mixed with a little litter or straw, as the manure will not heat well if too dense. It should be piled in a long, narrow, square-topped pile, should not be wet, and should be allowed to ferment. If the weather is cold and fermentation does not begin, the addition of a little hen manure to one part of the pile, or wetting the manure with hot water, will start the heating. In order to secure uniform fermentation, the pile should be turned occasionally and all lumps broken up. When the pile is steaming throughout, it is ready for the hotbed. The process of heating usually requires from four to ten days.

The hotbed may be made as early in the year as desired, but for common use, growing early tomatoes, lettuce, radishes, and the like, early in March is generally the best time. Care must be taken not to water the bed too much, as this will cool the manure and stop fermentation. The bed should be ventilated frequently during the warmest part of the day.

Cold Frames. A cold frame has no heat other than that derived from the sun. It consists of a frame of the desired size, with glass cover, so arranged that the bed may be ventilated. Cold frames are placed in a sheltered spot, near buildings, or in the open field, as desired, and the plants may be transplanted from them when settled weather arrives, or the frame may be taken up and the plants left standing where they started. Cold frames are used to harden off plants; that is, gradually to accustom

hotbed plants to the colder outer atmosphere, or to protect plants which can not endure severe cold but need no bottom heat.

Transplanting. Plants may be transplanted as soon as it is warm enough and one feels reasonably sure that the weather is settled. Strong, stocky plants are better for transplanting than large, spindling plants. The plants should be put into their permanent places just as soon as possible after they are removed from the hotbed or from the box. Just as many of the small roots should be pre-



Good tomatoes must be of good size, of good color, smooth, and uniform in outline, and must have a large proportion of flesh and a small proportion of seed cells.

served as possible. The soil in which the plants are to be placed should be warm, moist, and in good tilth. The roots of the plants should be spread as much as possible, and the soil well firmed about them. If the soil is not moist, the plants may well be watered, but never enough to make the soil wet and sticky. After transplanting is finished, the top soil should be loosened with the hoe or

the rake, so that it will act as a soil mulch. Transplanting is more successful if done in cool, moist weather. Plants which have been grown in a hotbed or in a warm room should be hardened off before being planted.

POTATOES

Potatoes are grown in every state in the Union and are of increasing importance and value. They furnish a very large amount of valuable food from a small area of land.

It is no longer necessary to store enough potatoes for the entire year's supply, for improved methods in the commercial handling of potatoes enable us to have comparatively fresh potatoes always available. By digging potatoes as soon as they are marketable, the southern states supply the market until the potatoes from the northern states are matured, thus insuring a continuous supply of good quality.

While the average yield is higher in the northern states than in the southern and the central states, the average profit to the acre does not vary much, because potatoes that are sold as new potatoes bring a much higher price.

In all regions where potatoes are grown in commercial quantities or on large areas, machinery is used for planting, digging, and spraying. Under these circumstances it is also necessary to employ a rotation and to use fertilizers rather freely.

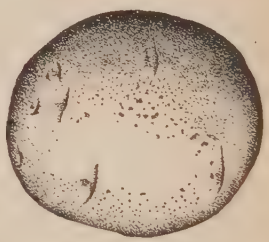
Growing Potatoes in Kansas. Potatoes should not be grown on the same field several years in succession in Kansas. A good rotation for most Kansas soils consists of wheat after potatoes, alfalfa sown in the fall after the wheat, alfalfa three to five years, corn for one or two crops, and potatoes for one or two crops after the corn.

Barnyard manure applied one year before the potatoes

are raised has been found to give good returns. If applied immediately before the potatoes are to be grown, it is liable to be a detriment for the first season if the weather is dry. The potato field should be thoroughly and deeply plowed late in the fall. This puts the soil into better physical condition and may destroy many insects. Thorough disking in the spring before planting will put the ground into good condition for the crop.

The Early Ohio variety furnishes a large proportion of the potatoes consumed between June 1 and September 1.

Selecting Seed. The potatoes most desired by the market are of medium size, weigh from five to eight ounces, and are regular in form, having smooth skin and well-set eyes. If the eyes are too deeply set, waste is occasioned in paring the potatoes. An eye that is not indented usually lacks vigor.



The Bliss Triumph is round, pink, and smooth.

In selecting seed, care should be given to choose tubers which show the characters of the variety. Varieties differ in form, color of the skin, indentation of eyes, and character of flesh. It is important that oblong potatoes carry their form well to the terminal buds.

The Rural New Yorker is an oblong potato, somewhat flattened, and ranks high in quality.

In localities where earliness is essential, Early Ohio, Irish Cobbler, and Bliss Triumph potatoes are grown. Rural New Yorker, Burbank, and Carmen are later varieties. Quality seems to depend more upon conditions of

growth than upon variety. Northern-grown seed is preferred in Kansas.

Planting. Potatoes for planting should be of medium size. The size of the seed piece should vary somewhat with soil and weather conditions. In localities which have good soil and sufficient rainfall, but in which hot weather is likely to cause early maturity of the vine, comparatively small seed pieces planted thickly seem to give better results. The plants are not so vigorous and begin to set tubers earlier in the season. Growers in the Kansas valley usually plant one-eye pieces about twelve inches apart in the row, the rows being about three feet apart. The ideal of the growers there is to get an even stand and early setting of tubers. Planted in this manner, a full stand, producing to the hill four or five tubers weighing, when dug, four ounces each, is a very satisfactory crop.

In localities where the weather is cooler, the growing season longer, and the soil less fertile, better results are usually secured by doubling both the size of the seed piece and the distance between hills, securing a stronger plant in less time than by means of the smaller pieces. The cost of seed, the rental value of land, and the labor of growing must be considered, and the more profitable procedure adopted.

Cultivation. Cultivation should begin early. One advantage of using a machine for planting is the well-defined ridge over the row which makes it possible to "blind-plow" or cultivate before the plants appear. The purpose of cultivation for potatoes, as for other crops, is to prevent weed growth and to conserve moisture. After the plants have got to growing, the roots extend for a considerable distance, and cultivation should not be so deep as to injure them. If potatoes are to be dug early,

the soil is ridged but little. High ridging makes digging more difficult. If the tubers are to be left in the ground until late, it is desirable, after the tubers are well formed, to ridge rather high, in order to prevent the tubers near the surface from burning, and between rows, in order to afford drainage should heavy rains fall. Tubers rot rapidly if water stands on the ground in warm weather.

Sufficient horse power should be used to run the digger deep, the horses moving at a brisk walk.

Mulching. In localities where rainfall is sometimes deficient potatoes are often grown under a mulch of straw, which is applied either as soon as they are planted or just before the plants appear. It is a more expensive method than cultivation, but many farmers who farm large areas to wheat or other grains would rather do extra work in early spring than take time from the harvest.

Digging. In digging, care must be taken not to cut or bruise the tubers. In digging large areas horsepower diggers do very satisfactory work. In sandy soil elevating

diggers are sometimes used, but in any soil that is liable to form clods picking and sacking by hand are more satisfactory.

Storing. Storage for potatoes should be cool and neither very moist nor very dry; too moist storage induces rot, while too dry conditions tend to wilt the tubers. If the crop is to be left in the ground until fall it is a good plan to plant some cover crop to use the moisture and shade the soil. Turnips make a good cover crop, and are sometimes of considerable value for market. When the potatoes are dug early the ground can be easily put into good condition for fall wheat or alfalfa.

QUESTIONS

1. What are the requirements for a good garden site?
2. Why should garden plans be made in the fall preceding the planting?
3. What factors determine the quality of vegetables?
4. What is the purpose of hotbeds and cold frames? How should you construct a hotbed?
5. What vegetable crops require transplanting? Why?
6. What are the essentials of good garden cultivation?
7. Why do potato growers practice rotation? Suggest a rotation for your locality.
8. What constitutes a good seed potato?
9. What machinery is necessary when large areas of potatoes are grown?
10. What are the advantages of mulching?
11. What conditions are necessary for storing potatoes?

CHAPTER XXXIV

BEAUTIFYING THE HOME GROUNDS

Beautifying the home grounds should interest every member of the family. If the work is well done, it increases the value of the property and adds to the comfort and happiness of the home. An expenditure of a very few dollars in the purchase of ornamental shrubs and flowering plants will bring surprising results. A careful study of nature is the best guide in planning the grounds. Learn from the arrangement of shrubs and

A well-planted city yard.

plants in the fields, on the hills, and along the banks of streams near the home place. The best arrangement is secured by tastefully grouping trees, shrubs, hardy perennials, and annuals. Residents of country and sub-

urban homes have opportunities for beautifying their home grounds that are not possessed by the man who owns a home in the city. Suburban and country homes are able to give over large areas of land for lawn purposes, but the city man has to be content with a space fifty by fifteen feet or smaller. Large lawns admit of a great variety of plants and permit the owner to develop pleasing effects that would be impossible on a small lot.

Shrubs. Careful selection of the best hardy plants growing in the vicinity will secure pleasing effects at a small outlay of labor. Such materials are vastly more practical for Kansas planting than many of the highly advertised novelties of the nurseryman. Dogwoods, sumachs, elderberries, wild gooseberries are much hardier and better adapted to Kansas conditions than are rhododendrons, Japanese maples, mountain laurel. Among shrubs valuable for the greater part of this state is Thunberg's barberry, which grows three to four feet high, with yellow flowers and red fruit, is a good hedge plant, and is useful for border plantings. Growing taller but just as useful are the common barberry and the purple-leaf variety. Bridal-wreath spirea, with its graceful arching branches and white flowers, is a delightful object in the landscape. Japanese quinces, especially the red and the white variety, should be included in every list. They bloom early and profusely, and occasionally bear green fruits. Lilacs in variety, too well known to need description, and the mock orange, that grandmother used to grow, are deserving of a place on the list. For arid regions the Siberian pea, the Russian olive, and the bladder senna will prove their worth.

Shrubs should be arranged in groups rather than as single specimens. Plant them near the angles of build-

ings and the curves of walks and drives, and use taller plants in the background.

Shrubs require very little care and will thrive in almost any soil and situation. Varieties may be selected for high, dry locations, or for low, wet places; many grow best in sunny situations, while a few will thrive under the shade of other trees. Pruning shrubs consists in taking out dead and crossed branches except in hedges. Shrubs may be set either in the spring or in the fall.

A well-trimmed hedge adds much to the appearance of the place.

Vines. Another important factor in beautifying the home grounds is the hardy vine suitable for covering brick, stone, and wood. A working list of climbers should contain Virginia creeper, Boston ivy, trumpet vine, wistaria, honeysuckle, clematis, roses, grapes, and climbing bittersweet. For porches, clematis, roses, and honeysuckles are the best, while stone structures welcome the cooling shade

of the Virginia creeper. Brick buildings may be covered with Boston ivy. Trellises and old fences are improved by a covering of trumpet vine or wistaria. It is difficult to find plants better fitted for hiding unsightly objects than the hardy climbing vines.

Grasses. Lack of appreciation is directly responsible for absence of ornamental grasses in many dooryards.

A triangular flower bed. Center, castor bean; second row, canna; third row, elephant's-ear; fourth row, salvia; fifth row, white vinca; sixth row, sweet alyssum.

These grasses present coloring impossible to secure by any other means. They are of rapid growth and perfectly hardy. These plants may be used as single specimens on the lawn, may be planted with other grasses or with shrubs, or may serve as the principal object in a perennial bed.

Trees. No planting is complete without a few ornamental trees. These trees will look much better if planted in irregular groups. Some of the more valuable varieties may, however, be used as individuals on the lawn, and it is well to arrange a few close to the buildings, for shade. Where conditions are favorable for their growth, there are few trees that can equal the different species of

oaks and maples. Hardier, perhaps, than those just mentioned and nearly as valuable are elms, hackberries, ashes, cottonwoods, and honey locusts. These trees present a great variety of form and size, texture, and color. Deciduous trees and shrubs insure beautiful autumn colors.

There is another class of trees that is valuable because of its winter effect. No landscape should be considered complete if there are no evergreens on the grounds. Winter and summer, their leaves are green. Planted with broadleaf trees, they form a pleasing contrast in color and form. Especially recommended for dry regions are the red cedar, the bull pine, and Sabin's juniper. These trees are more beautiful when the branches are permitted to grow from near the ground.

The Home Landscape Gardener. Shrubs, grasses, and trees, then, are some of the tools that the home landscape gardener has at his command. To use these tools skilfully requires some knowledge of the principles of landscape gardening. Here are a few: plant trees and shrubs in masses and groups; use curved lines as much as possible; strive for unity, variety, propriety, character, and finish. Do not overplant, as overplanting makes the grounds appear smaller. Provide for distant views by means of open vistas. A well-arranged plan will be a source of delight, not only to the author, but to the many visitors and to those who pass the place.

FLOWERS

The arrangement and the care of flowers on the home grounds may be considered from two standpoints, that of the flower garden and that of the flower bed.

The Flower Garden. The flower garden should be large enough to include all the best flowering plants that are not suitable for lawn planting. This garden should

be situated in the rear of the house or the greenhouse, and may be laid out in rows or beds, or both. Here is the haven for annuals and perennials; here is the place for experiments and study: yet such a garden can be

A circular flower bed for the back yard. Center, castor bean; second row, canna; third row, caladium, or elephant's-ear; fourth row, salvia; fifth row, white vinca.

so arranged as to give enjoyment to those who worship the beautiful.

Flowering plants that have a long period of growth before flowering, like the China asters, should be relegated to the flower garden. "Beautiful they are while in bloom, but their beauty fades all too quickly." Sweet peas, roses, tuberoses, zinnias, flags, columbines, peonies, hardy phloxes, hardy asters, many of the ornamental grasses, some shrubs, and several bulb-forming plants furnish splendid material for building up the flower garden.

The size of the flower garden will depend largely on the amount of ground available for such a purpose. After deciding upon the location and the size, draw a plan of the garden, indicating walks, beds, and the names and the number of different plants. Adhere strictly to this plan unless there is some very important reason for making a change. Several authorities suggest the laying out of the flower garden in geometrical figures. This increases the work and adds an artificial appearance to the garden.

Flower Beds. Some of the simpler forms of bed are the circle, the triangle, the rectangle, the square, and the irregular outline. Any of these may be easily constructed. Their future usefulness depends entirely on good taste in selecting plants to fill them. On small estates a simple design is much better than scroll work or complex figures. One word of caution, however—do not cut the lawn to pieces with too many flower beds. A few, well arranged, will be a source of delight and satisfaction, but it is necessary to use sound judgment.

Thorough preparation of the soil is an absolute necessity. Dig deep, at least two feet, and enrich the ground with either barnyard manure or commercial fertilizer. A layer of well-rotted manure spaded into the soil will always be beneficial. If the soil is very thin and poor, remove it to the depth of two feet and fill the space with rich, porous loam. For the best success with the home flower garden, plenty of water is necessary. Water pipes, with fifty or a hundred feet of rubber hose, will lessen the chances of failure twenty-five per cent. Flower beds in Kansas should be made level with, or a little below, the surrounding ground, so as to catch all the moisture possible.

The location of the different kinds of plants will depend upon the needs of each variety. Many plants succeed

well in a shaded location, while others require plentiful sunlight. A mixed bed, unless made up of perennials, is not so effective as a mass of one kind or color.

Ornamental flower beds, if properly handled, give the lawn an appearance of life, and add materially to the variety of the landscape. In laying out the flower beds, knowledge of how large each plant will grow, what color of flower, if any, it will bear, and how much pruning it will stand, is extremely important. A flower bed with sweet alyssum and lobelias in the center and cannas and castor beans around the outside would have the proper ingredients, but would be lacking in taste.

A few simple beds may be arranged thus, in circular or other shape:

Inner row.....Coleus, Red Verschaffelti.
Second row.....Coleus, Gold Bedder (yellow leaves).
Third row.....Achyranthes (red).

Inner row.....Snapdragon (cream-colored).
Second row.....Phlox (choice).
Third row.....Verbena (choice).

Inner row.....Canna (red- or green-leafed, large flowering).
Second row.....Salvia (Red Sage).
Third row.....Vinca (pink.)
Fourth row.....Vinca (white.)

Inner row.....Century Plant.
Second row.....Coleus (yellow).
Third row.....Alternanthera (red).
Fourth row.....Alternanthera (yellow).

Inner row.....Banana.
Second row.....Caladium.
Third row.....Dwarf Canna (red-leafed).
Fourth row.....Dwarf Canna (green-leafed).

Inner row.....Tulips (red).
Second row.....Tulips (red).
Third row.....Tulips (yellow).
Fourth row.....Tulips (pink) or Dutch Hyacinths (varicolored).

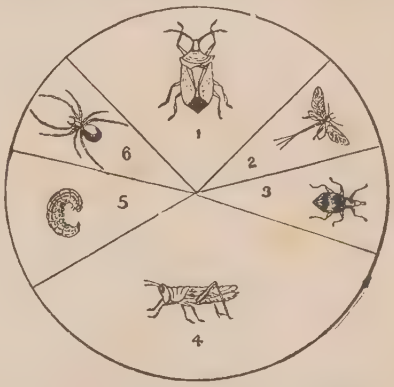
QUESTIONS

1. What is the practical value of planting trees, shrubs, and flowers on the home grounds?
2. In selecting shrubs for the home grounds, what points should be considered?
3. Name three shrubs suitable for planting in arid regions.
4. Discuss the care and pruning of shrubs.
5. Explain the uses to which vines may be put.
6. Why should evergreens be given a place on the lawn?
7. Explain the principles of landscape gardening as applied to home planting.
8. How do flower beds differ from flower gardens?
9. Give concise instructions for the preparation of soil for the flower bed.
10. What arrangement of flowers should be made for a circular flower bed ten feet in diameter?

CHAPTER XXXV

BIRDS

Birds have always been appreciated for their songs and bright colors, but it is only recently that people have realized their great economic value. The United States Department of Agriculture and many students have learned much about the habits of birds, especially their feeding habits. What various birds eat during the day is learned either by observation or by an examination of the contents of their stomachs. Through such studies it has been discovered that birds are very important, and now in most states they are protected either by state or by national laws. All the Kansas birds save one are protected at least to some extent by state and national laws. A statement of the bird law may be obtained from the State Fish and Game Warden at Topeka, Kansas.



The food of the house wren. 1, Bug; 2, May fly; 3, weevil; 4, grasshopper; 5, cutworm; 6, spider.

The most common and helpful birds feed upon seeds and insects. A few birds on a farm perform a great service to the farmer. Winter birds are especially helpful, for every

seed or insect destroyed in winter is equivalent to several hundred destroyed the next summer. The disappearance or the sudden reduction in numbers of birds in a locality, is frequently followed by an alarming increase in the hordes of destructive insects, and at times by an unusual growth of weeds. If properly encouraged and protected, the birds on the farm will increase and become exceedingly helpful to the farmer.

When Birds are Helpful. The time when birds are most helpful depends upon where they spend the different seasons of the year. Everybody knows about the migration of blackbirds, robins, bluebirds, and hosts of others. But there are many birds about which most of us know little.

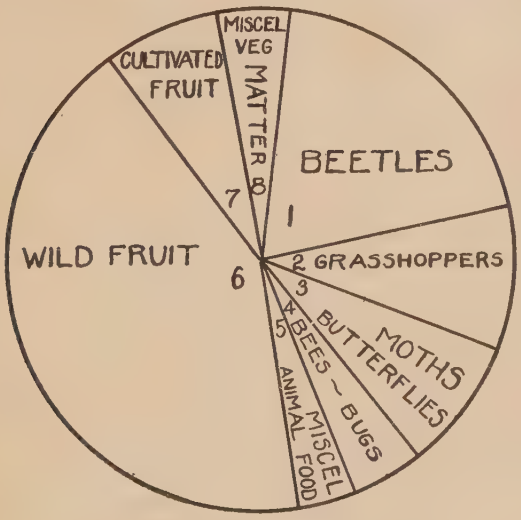
Those birds which are here only for the summer are called summer residents. In the autumn, when food becomes scarce, they leave, some of them singly, some in pairs, and many in flocks. They go for the most part at night. The flights average perhaps twenty-five miles every twenty-four hours. Of course, birds halt, pass each other, and linger along as food and weather permit. These birds spend the winter in the Gulf States, Mexico, Central America, the Bermudas, and the West Indies. Blackbirds, orioles, warblers, blue jays, bluebirds, and meadow larks belong largely to this class, though some of these remain here over winter.

A few species of birds from farther north find the climate of Kansas so agreeable that they spend the winter here rather than farther south. These are called winter sojourners. Certain shrikes, snowbirds, waxwings, and native sparrows belong to this group. Still others—the residents—stay here the year round. In this class may be included a few blue jays, bluebirds, meadow larks, robins,

and redbirds, and nearly all of our owls, hawks, quails, chickadees, nuthatches, horned larks, and woodpeckers.

Members of another group, called the migrants, are found here only as they pass through the country in their spring or autumnal flight. The most numerous example of these are the water fowls. Unlike the song birds, they usually fly in daytime.

Protectors of the Orchard. The chickadee, the nuthatch, the titmouse, and the brown creeper are very helpful in the orchard. These and the downy and the hairy woodpeckers render great service by searching in tiny



The food of the robin.

holes and crevices for small insects and insect eggs. By fastening bits of suet, scraps of meat, or broken bones to branches of trees, one may encourage birds to frequent an orchard.

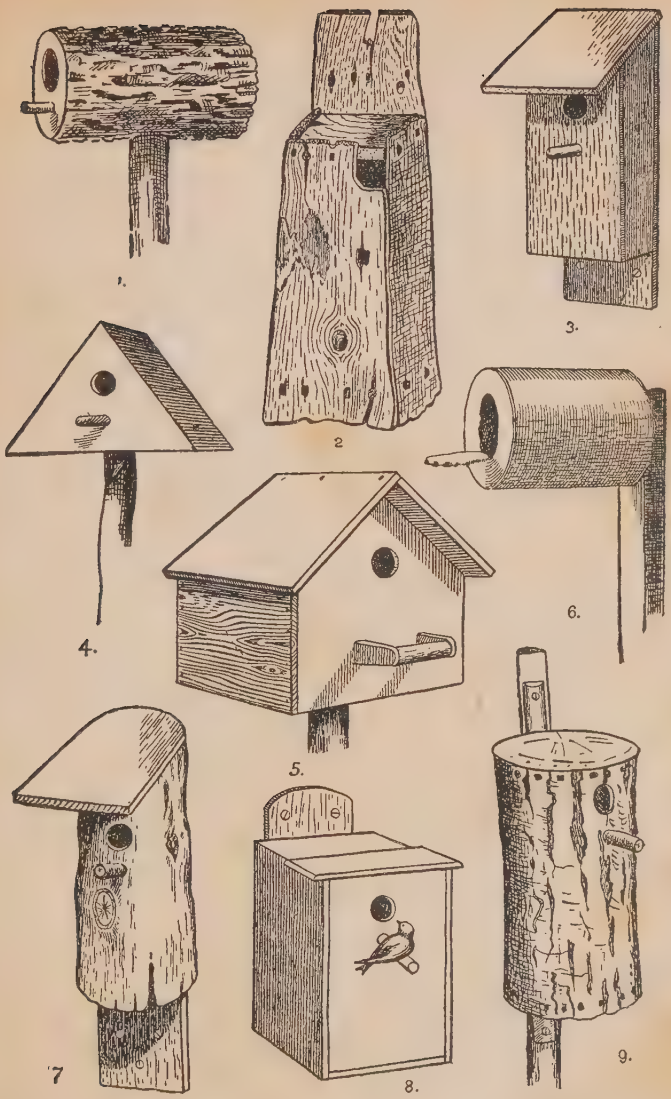
Robins, catbirds, brown thrashers, mocking birds, and

orioles also render great service to orchards, groves, and gardens. The little fruit taken by these birds by no means equals in value what they save from destruction by insects. Some smaller summer birds, such as warblers and wrens, feed among the trees, on insects that infest the foliage.

Protectors of Field and Garden. A great number of birds help to protect the farmer's field crops. Some of them help chiefly by eating weed seed, while others feed upon both seeds and insects. Four or five species of native sparrows and the longspurs, or snowbirds, are especially valuable because of the enormous numbers of weed seeds which they destroy. Sometimes one of these birds eats more than a thousand seeds in a single day. Meadow larks and blackbirds feed upon both seeds and insects. These birds continue their work throughout the year. In summer they destroy immense numbers of insects and insect larvæ, while in winter they feed chiefly on seeds.

The quail is perhaps the farmer's most valuable and faithful friend among the birds. This bird eats great numbers of pigweed, ragweed, pigeon grass, and other weed seeds. Quails also destroy many insects which other birds seldom or never eat and which are especially destructive. Among these are the potato beetle, the cucumber beetle, and the chinch bug. Farmers should protect and encourage these birds by supplying them with shelter and food in winter. Strips of sorghum, kafir, and other crops left in out-of-the-way places serve these purposes.

Other Bird Friends. Hawks and owls render great service by destroying mice, gophers, ground squirrels, and even rabbits. They, too, work throughout the year. These birds are frequently misjudged, and many harmless ones are often destroyed. Most large hawks seldom if ever touch poultry. Two or three species of hawks and the



Bird houses. 1. Section of hollow limb; 2, rough shingles; 3, shed-roofed house; 4, A-shaped house, 5, gabled house; 6, tomato can; 7, hollow limb; 8, box house; 9, willow-bark house.

large "hooter" owl are the only ones which frequently or habitually attack poultry. None of these birds should be destroyed until the farmer is sure they are destroying poultry. Nighthawks, swallows, kingbirds, and many others are helpful and should be protected.

Protecting and Encouraging Birds. One may encourage birds to remain about the farm by furnishing them with suitable nesting places, making sure that they have a place to get water, and in severe weather furnishing them with food. A thicket of native shrubs in a favorable place will serve not only as a windbreak, but also as a bird home.

One should learn to know the birds and their habits, to appreciate their beauty and friendliness, to value their services, and to help repay in little kindnesses the great service that they render.

QUESTIONS

1. In what way are birds helpful to the farmer? How has this been proved?

2. When are the various kinds of birds most helpful? How is it possible for winter birds to be helpful?

3. Name some of the birds which help to protect the orchard. How do they render this service?

4. Discuss in the same way the birds of the fields and garden.

5. Name some birds generally believed to be harmful, and tell how they are helpful to farmers.

6. How may farmers and their families help the birds?

CHAPTER XXXVI

GOOD ROADS

An intelligent business man or manufacturer seeking a location for his plant gives first consideration to the means for transporting his products. Farming is a business, and the farm is the plant. The product of the business must be transported, and the farmer, as much as any other business man, needs to consider the means of transportation. A road system is a means of transportation, just as a line of boats or a railroad system is a means of transportation.

The Importance of Good Roads. Good roads are so important to the financial, social, and educational well-being of the community that no enumeration of their advantages is likely to include all the benefits. Extending in various directions, they form the arteries of life of the town or community. They are the currents of traffic, and, as such, their condition frequently means profit or loss on the sale of produce or determines the ability of one community to compete with another.

Good roads add to social advantages. Good roads strengthen the country church, tend toward better living, and bring a good class of citizens into the community. They do this because they permit easier travel between the people on the farms and the people in the cities. Good roads also encourage the extension and improvement of rural mail and parcel post service. They also make possible better educational and religious advantages for the farm boys and girls.

Good roads reduce the time and the cost of transportation. To be able to haul large loads is important in marketing crops and heavy articles. To get material to market quickly is important in handling perishable products, or during the busy season. Both of these advantages come with good roads. On ordinary roads it costs from twenty to fifty cents to haul a ton a mile. This is four times as much as the cost on a good road. By making the

A good road. Farm products can be marketed in any kind of weather 365 days in the year, on this highly improved macadam road in Cowley county.

road surface smoother and harder throughout the year, we can make a great saving in time and in cost of hauling.

Good roads enable a farmer to market his products at all times of the year. He can always get things to market when prices are high or when he can not work in the field, and he is not in danger of losing produce because it spoils before he can market it. This is especially important in the case of dairy, poultry, orchard, and garden products. Roads which can be used at any season or in any kind of

weather help to equalize the farmer's work and prevent a rush season.

Good roads help reduce the high cost of living. Lowering the cost of hauling helps make products cheaper. Ability to use the roads at all times enables us to market and use home-grown fruits and vegetables which otherwise would spoil and necessitate the shipping in of similar products. The farmer can come oftener to market with such products and so prevent loss to himself and the merchant, and thus reduce the price to the consumer. Good roads benefit buyer and seller, in the country and in town, and help every member of the family, boys and girls as well as men and women.

A bad road. The most expensive type of road.

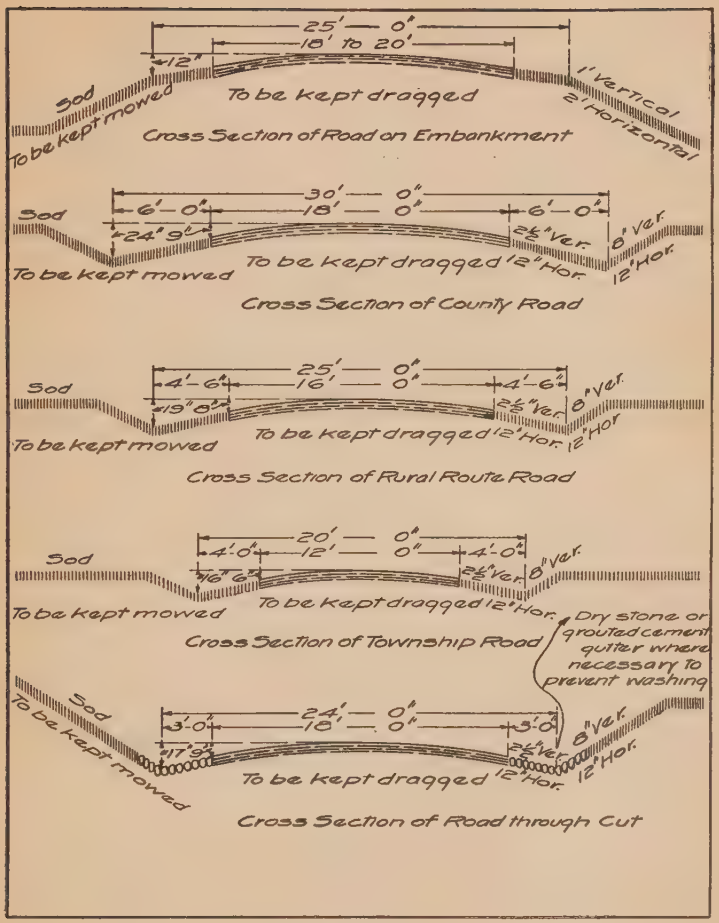
Locating a Road. The early trails and state roads of Kansas were properly located on the best ground obtainable, regardless of section lines. The first legislative act declaring the section lines to be the center of the highways was passed in 1860. This applied, however, only to Brown

county. In 1871 the section lines in fourteen other counties were declared to be the centers of the public highways, and from that time on the roads have been laid out almost exclusively on the section lines, regardless of proper location, hills, character of soil, safety of traffic, first cost, maintenance expenses, or convenience or economy of traffic. As a result of this poor method of locating roads, thousands of dangerous, unnecessary railroad grade crossings and expensive bridges are maintained. Wherever it is practical, the highways should parallel the railroads instead of crossing them, go around the hills instead of over them, and avoid all unnecessary stream crossings. In other words, all public highways should be laid out on the sensible, practical, natural locations. In no case should the public good be sacrificed for the interest of the individual.

The Width of Roads. There is a tendency to lay out public highways wider than is necessary. This is a poor practice, for any extra width not only means a loss of valuable land to the farmers and to the state, but is an absolute detriment to the road, as the extra width only gives a place for weeds and brush to grow. Also, when roads are too wide, inexperienced road officials often waste public money in trying to grade up and maintain roads forty to sixty feet wide between the centers of the side ditches.

For state or county roads the width of the right of way need not exceed sixty feet, except in special cases where heavy cuts or fills are necessary. On township roads the right of way need not exceed fifty feet, except in special cases.

The cross sections for the different classes of roads shown in the accompanying figure give such width, crown, and shape of side ditches as have proved satis-



Drawings giving details for building various kinds of roads.

factory for average Kansas conditions. In heavy clay and gumbo soils, the crown of the road should be increased to provide good surface drainage.

The distance between curbs on paved streets in resi-

dence districts of cities is from twenty to forty feet, averaging about thirty feet. This is ample width to accommodate the traffic and to leave space for a parking on either side, which materially reduces the first cost and maintenance expenses of paving, and adds beauty to the street.

The Classification of Roads. The commissioners of each county in Kansas are required to classify the roads, according to their relative importance, as state roads, county roads, mail routes, and township roads. State roads are highways which have been designated as such by the legislature; county roads are the highways connecting the cities and the market centers, and are located as nearly continuously from one county to the next as practicable; mail routes are such highways used by rural mail carriers as have not been designated as state or county roads; all other public highways are township roads.

State and county roads are constructed and maintained under the direction of the three county commissioners and the county engineer at general county expense. The highways designated as mail routes and township roads are constructed and maintained by the three township highway commissioners and the county engineer at township expense, except that the county is required to pay for the construction and maintenance of all bridges costing more than $200.

Expenditures for Roads. There are about 110,000 miles of public roads in the state, and in round numbers the counties and townships of Kansas spend $5,000,000 annually for country roads. This amount exceeds the total cost of running the state government, including all the state educational and charitable institutions, and equals almost one-half of all the expenditures for public schools.

Probably as much as $35,000,000 has been spent in the last ten years on roads, bridges, and culverts, chiefly in

keeping the roads in repair. Less than one per cent of the roads have been surfaced with clay, oil, macadam, gravel, concrete, and brick, and probably less than twenty-

A concrete bridge. The permanency of this structure is plainly evident.

five per cent of the earth roads are kept thoroughly dragged.

About $3,000,000 has been paid annually for the construction and maintenance of bridges and culverts, many of which were built of steel, wood, and corrugated metal, and must in a comparatively short time be replaced. If good stone or concrete had been used the cost would have been little, if any, increased, and the structures would have been permanent.

Not less than $1,500,000 annually has been spent on earth roads. A small part of this has been used for reducing grades and performing permanent work, and a part for dragging.

Road Management. Usually there are too many road officials, most of whom are untrained. One-third of the present number of road officers could, if trained, do the work more efficiently and economically than it is now done. Road making is a business, and a good road officer should be educated for this work. He should not be

a busy farmer who must neglect either his road work or his farm business.

Some of the better features of road management in the various states are:

1. A state highway office which has general supervision of road and bridge work, establishes standards for

A concrete culvert. This culvert in Wabaunsee county will require no repairs and will last forever.

road and bridge construction, assists and advises county engineers, and generally organizes and systematizes the work.

2. A county engineer, who is a trained road and bridge builder, selected by civil service, and is a deputy of the state highway office. He works under the authority of the county officials and has general supervision of the road and bridge construction and maintenance work in the county. His approval is required for plans and specifications and for all materials and machinery purchased.

3. The selection of all overseers and supervisors for their ability and training. They are employed as nearly

continuously as possible, so that road making may become their business. They report directly to the county engineer.

A well-organized system of road management which will put road making in the hands of experts always results in better and more permanent roads at less final cost to the people.

Road Drainage. Drainage will often change a bad earth road to a good one. On poorly drained roads, rain and snow soften the earth, the horses' feet and the wagon wheels mix and knead it, and soon the road becomes impassable. If the water is allowed to run down the middle of the road it will wash away the road material and leave ruts in the surface. No road, however good it may be otherwise, can last long if water collects or remains on it. Prompt and thorough drainage is important in all road construction, particularly the construction of earth roads. There can be no good roads without it.

In making a good road it is necessary to provide for both surface drainage and underdrainage. The surface drainage of a road is provided by rounding up or crowning the traveled section and keeping it smooth. The slope from the center to the sides should be sufficiently steep so that the water will be carried freely and quickly to the side ditches. If the surface is kept smooth and free from ruts and holes, less crown will be required. The amount of crown necessary varies with different kinds of soil. A sandy soil may drain well and give entire satisfaction with a crown of one-half to three-quarters of an inch to the foot, but in heavy clay or gumbo one and one-half inches to the foot may be required to provide adequate fall to carry the water away from the center of the road freely. For ordinary soils a crown of about one inch to the foot is generally satisfactory. This provides sufficient fall to get rid of the water, and is comfortable for driving.

The side ditches are constructed to collect the water from the surface of the road and to intercept that which comes in from the fields. They should have a continuous fall to enable the water to be carried rapidly and entirely away from the road. The side ditches should have a continuous uniform grade from the highest point to the nearest outlet, and should be made wide and flat so that if a team is crowded or shies off the road there will be little danger of the vehicle's overturning. Water does not flow so rapidly in a flaring ditch as in a V-shaped one, and if the water is spread out in a thin sheet the grass and weeds and the rough surface of the ground obstruct its flow very materially. When the sides are made steep, however, only a small amount of water will have a considerable depth. This condition gives the water a high velocity which carries everything before it, and in a short time great gullies are formed. If possible, the side slopes should be shaped so that a mowing machine can be used to cut the grass and weeds which grow upon them.

At all wet, low places in a road tile drain should be employed to lower the water table. Tile is cheap, and, if placed in a substantial manner and according to the rules of common sense, will last for ages.

Earth Road Construction. Nearly half of the road-grading work in Kansas is done between October 1 and January 1. This practice of grading the roads in the fall is wrong, for the money so spent is generally wasted, and many times the road is worse than it would have been had it not been touched, for there is not a sufficient length of time after the grading is done to compact the loose earth before winter.

Grading must be done when the ground is wet enough to be worked and compacted well, and to form a good wearing surface. This can best be done by grading before

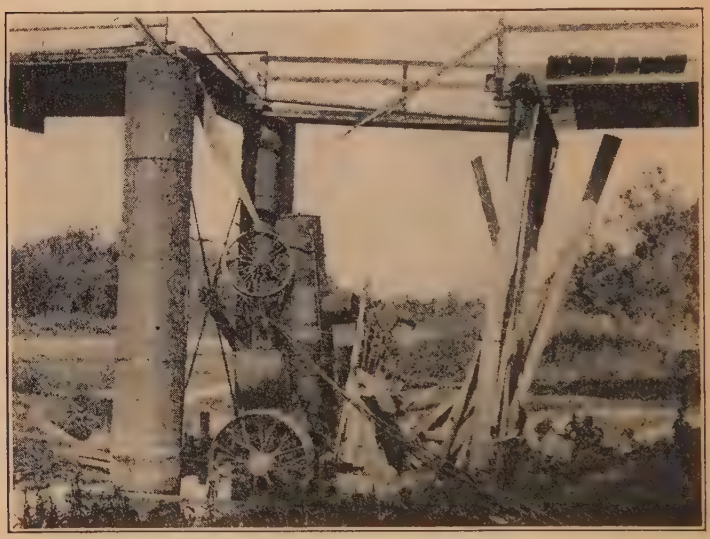
August 1—the sooner after April 1 the better. In the spring or early summer the ground is loose and will work easily, and the roots of the grass and weeds do not interfere at this season.

Using the Grader. In the building of new roads with a road grader the dead weeds and grass should be burned off before any grading work is done, and the width

A so-called permanent patented reinforced concrete arch bridge after six months' use. The structure was 250 feet long.

of the road to be graded should be staked so that the side ditches can be properly lined up; then a light furrow should be plowed with the point of the grader blade to mark definitely the lines of the ditches. The work then should be continued until the entire width to be graded has been well rounded up, including cutting off the material on the outside of the ditches to a slope of about one foot vertical to one and one-half feet horizontal. Then the road should be filled full and round, and the loose material thoroughly harrowed with an ordinary straight-tooth harrow, if there are no clods, until the bumps have been leveled off and

the low places filled up and the material has been well compacted. If there are sods or tough lumps of earth in the road a disk harrow should be used to pulverize this



This bridge was practically new when the engine attempted to cross but broke through and fell twenty-five feet, killing the driver.

material, and the harrow should be followed by a road drag or a straight-tooth harrow to level and smooth the earth. No newly graded earth road can be finished in good shape without the use of a harrow or a drag, or of both. To compact the earth, a roller should follow the harrowing. It will reveal the soft spots, and new material can be placed in these and the whole surface made smooth, even, and uniform. If the earth is thoroughly compacted and the small depressions are removed, ruts will not form nearly so readily, and heavy rains will not cause great gullies, such as are often seen on newly graded roads after a heavy rainstorm.

It costs from $15 to $50 a mile to grade an ordinary earth road thirty feet wide. The cost depends upon the soil and the condition of the road, the time when the work is done, and the price of labor.

Earth Road Maintenance. Every spring, before the ground becomes too hard, the road should be gone over thoroughly with the road grader, to clean out the ditches,

A road drag.

so that the water may have a free outlet. Ruts and holes should be filled, elevations in the road and shoulders on the side of the road should be planed off, and the road should be put into good condition generally.

Earth roads have a pronounced tendency to form ruts. When ruts begin to appear on the surface, they should be immediately filled with carefully selected new material. A fundamental principle in the repair of any road is that, whatever material is used in the construction of

the surface, the same material and no other should be used in its repair. A road with a surface of clay should be repaired only with clay, a gravel road with gravel, and a surface of limestone with limestone. In road surfacing, however, a clay road is often improved by the use of sand, and a sand road by being surfaced with a foot of clay.

Every hole or rut in the roadway, if not stamped full of the same material as that of which the road is con-

One of the most dangerous and most inexcusable places in the road.

structed, will become filled with water and will be made deeper and wider by each passing vehicle. A hole which could have been filled with a shovelful of material will soon need a wagon load. To repair a rut or mudhole, it should be cleansed of dust, mud and water; then just a sufficient amount of good fresh earth should be placed in it to bring it even with the surrounding surface after being thoroughly consolidated with a tamper or roller.

In no case should sod be placed in or on the road surface, nor should the surface be ruined by having thrown

upon it the worn-out material from the gutters along the sides.

When an earth road has been properly crowned and adequate drainage has been provided, there is no other method of maintaining it in good condition so effectively, so economically, and with so little effort, as the constant use of the drag.

Bridges and Culverts. Much as we need improved roads, we need permanent bridges and culverts more; for, if the road is to be used at all, the bridges and culverts must be in good condition. We now know that if bridges and culverts are built of first-class concrete or of good stone there will be practically no maintenance charges and the structures will be almost everlasting. Therefore, only such materials should, whenever practical, be used in constructing bridges and culverts. Concrete or stone work, to be permanent, must be built in compliance with standard engineering practice, under rigid inspection.

If bridges and culverts are to be permanent, they not only must be properly designed and well built, but must also provide adequate openings to carry the water and ample width of roadway to carry modern traffic with safety.

Many bridges and culverts are built entirely too small to carry the water that will come to them. All small bridges and culverts in Kansas should be large enough to provide about one hundred square feet of waterway for each square mile of watershed; that is, a small bridge or culvert carrying the rainfall from 640 acres of land should have an opening about ten feet long and ten feet high. The roadway of each of these structures must be wide enough to permit the passage of all farm machinery and ordinary traffic. All bridges should have a clear width of at least eighteen feet to care for this traffic safely, and culverts,

those structures having a span of less than ten feet, should in no case have a roadway of less than twenty feet in the clear.

QUESTIONS

1. In buying a farm home, why should the conditions of the highways be considered carefully?
2. What are some of the benefits of good roads to the farmer?
3. What are the disadvantages of locating roads on the section lines?
4. Where should the roads be located?
5. Why are wide right of ways objectionable?
6. What should be the graded width of roads for the different classes of highways?
7. Define a state road; a county road; a mail route; a township road.
8. How are the different classes of roads managed, and how is the work paid for?
9. What are some features of a good system of road management?
10. Since thorough drainage is an absolute necessity in the construction and maintenance of a good road, how can it be obtained?
11. What is the proper time to grade roads?
12. In constructing a road with a grader, how should the work be done?
13. How should an earth road be maintained?
14. Why is the drag an efficient road tool?
15. Why do concrete bridges sometimes fall down?
16. How large an opening must a culvert have to carry a six-inch fall of rain from 160 acres of land?
17. How wide should the clear roadway be on bridges and culverts?

APPENDIX

SUGGESTIONS TO THE TEACHER

The teacher should keep constantly in mind that the teaching of agriculture, in at least two respects, closely resembles the teaching of English. First, we are dealing with material about which the pupil knows considerable and with which he has had more or less experience. For that reason the pupil is able to cover more ground than in subjects with which he is wholly unacquainted. Second, just as the chief problem of the teacher of English is to correct wrong habits of speech and show the reasons for proper usage, so the teacher of agriculture must endeavor to give such information as will lead to the abandonment of poor agricultural practice, and must at the same time teach thoroughly the reason underlying the better practice. Two suggestions follow from this: (1) Do not drag the work along and tire the pupils with needless discussions of things which their experience will enable them to grasp instantly; (2) Emphasize principles or reasons underlying practice. Scarcely any rule of agricultural practice can be laid down which applies universally, but fundamental principles may be taught which can be constantly and intelligently applied. The study of agriculture is a study of these principles and their application, rather than an attempt to master a mass of detail concerning agricultural practice.

Correlate this work with reading, spelling, composition, and drawing. Make agriculture felt throughout the school just as it must be felt throughout the pupil's life.

This book is made larger than the ordinary textbook in

order that supplemental reading matter may not be so necessary, but the live teacher will not neglect to encourage and train pupils to use other literature. The farm papers which come to homes in the district, bulletins, reports of the State Board of Agriculture, and reference books should be used.

Agriculture is primarily a study of things, and the child should learn from the object itself and by action where possible. Especially in the fall and the spring the teacher should take trips with the class when possible. A trip may be made to a field to study flowers, roots, soils, or weeds. The object may be a summary or review of what has been learned about a crop such as corn, sorghum, or alfalfa. It may be to inspect a newly seeded or sprouting field of wheat, or to learn something of the physical condition of the soil in a field which has had special treatment. Some of the work may be much better done indoors. Pupils may practice budding and grafting and even demonstrate pruning in a small way by using branches of trees. There may be exercises in grain judging, fruit judging, and seed testing. Some seed testing should, if possible, be done by each pupil. The chief problem here is to keep the schoolroom warm enough at night to prevent freezing. Test not only corn, but alfalfa, garden, and other seeds.

Many schools may well have a hotbed on the grounds. Building the frame, digging the pit, and other necessary tasks will furnish healthful exercise for the pupils at noon and at recess. Usually old window sashes may be borrowed and the frame made to fit them. Such a hotbed should be used to start plants which pupils may take home and plant in the home garden. Such plants as tomatoes, cabbage, peppers, sweet potatoes, and ornamental or flowering plants, may be started. This work will very

quickly carry the teaching into the home practice. This is the only kind of school gardening practicable in most country schools.

Do not neglect some attempt to improve the school grounds. If you do nothing more, clear off the stones, weeds, and other trash. Usually the teacher can help arrange the playground so that it will present a neat appearance, and she may even secure some apparatus. Where any care can be given during the summer, some shrub or tree planting should be done. Evergreen and other trees may be obtained from the State Forester, Kansas State Agricultural College, Manhattan, Kansas.

Do not neglect the work of Boys' Corn Clubs and Girls' Canning Clubs. These organizations will help to vitalize your teaching of agriculture. Information concerning these clubs may be secured from the United States Department of Agriculture, Washington, D. C., or from the Kansas State Agricultural College, Manhattan, Kansas. Application to the Division of Publications, Department of Agriculture, Washington, D. C., will bring a list of government bulletins classified for the use of teachers.

REFERENCE BOOKS

The following list contains the names of some of the better of the recent books on farming. The list is by no means complete. It does not include technically scientific books, nor books devoted entirely to specialties. All the books in the list have been written by men who are thoroughly dependable. None of the popular compilations on agriculture upon which little or no dependence can be placed, have been included.

From this list the teacher and the board of education may select books which not only will furnish supplementary work for the school, but will be a complete library of

ready reference for the farmers in the community. A few well-selected books from this list should be a part of every school library.

FOR THE TEACHER

COULTER, J. G., and PATTERSON, A. J. Practical Nature Study. New York: D. Appleton & Company. $1.35 net.

CALL, L. E., and SHAFER, E. C. Laboratory Manual in Agriculture. New York: The Macmillan Company. 90 cents net.

SOILS

VIVIAN, ALFRED. First Principles of Soil Fertility. New York: Orange Judd Company. $1 net.

BURKETT, C. W. Soils. New York: Orange Judd Company. $1.25.

WHITSON, A. R., and WALSTER, H. L. Soils and Soil Fertility. St. Paul, Minn.: Webb Publishing Company. $1.25 net.

FLETCHER, S. W. Soils. Garden City, N. Y.: Doubleday, Page & Company. $2 net.

FARM CROPS

WILSON, A. D., and WARBURTON, C. W. Field Crops. St. Paul, Minn.: Webb Publishing Company. $1.

LIVINGSTON, GEORGE. Field Crop Production. New York: The Macmillan Company. $1.40 net.

MONTGOMERY, E. G. Corn Crops. New York: The Macmillan Company. $1.60 net.

HUNT, T. F. The Cereals in America. New York: Orange Judd Company. $1.75.

HUNT, T. F. The Forage and Fiber Crops in America. New York: Orange Judd Company. $1.75.

BORMAN, T. A. Sorghums: Sure Money Crops. Topeka: Kansas Farmer Company. $1.25 net.

ORCHARDING AND GARDENING

SEARS, F. C. Productive Orcharding. Philadelphia: J. B. Lippincott Company. $1.50.

GREEN, S. B. Popular Fruit Growing. St. Paul, Minn.: Webb Publishing Company. $1.

BAILEY, L. H. Principles of Fruit Growing. New York: The Macmillan Company. $1.50 net.

BAILEY, L. H. Principles of Vegetable Gardening. New York: The Macmillan Company. $1.50.

GREEN, S. B. Vegetable Gardening. St. Paul, Minn.: Webb Publishing Company. $1.

LIVE STOCK

HARPER, M. W. Animal Husbandry for Schools. New York: The Macmillan Company. $1.40 net.

PLUMB, C. S. Beginnings in Animal Husbandry. St. Paul, Minn.: Webb Publishing Company. $1.25 net.

HENRY, W. A. Feeds and Feeding. Madison, Wis.: Author. $2.25.
PLUMB, C. S. Types and Breeds of Farm Animals. Boston: Ginn & Company. $2 net.
SMITH, H. R. Profitable Stock Feeding. St. Paul, Minn.: Webb Publishing Company. $1.50.
CRAIG, J. A. Live Stock Judging. Des Moines, Iowa: Kenyon Printing Company.
MUMFORD, H. W. Beef Production. Urbana, Ill.: Author. $1.50.
JOHNSTONE, J. H. S. The Horse Book. Chicago: Sanders Publishing Company. $2.
DAWSON, H. C. The Hog Book. Chicago, Ill.: Breeder's Gazette. $1.50.
CRAIG, J. A., and MARSHALL, F. R. Sheep Farming. New York: The Macmillan Company. $1.50 net.

DAIRYING

ECKLES, C. H. Dairy Cattle and Milk Production. New York: The Macmillan Company. $1.60 net.
WING, H. H. Milk and Its Products. New York: The Macmillan Company. $1.50 net.

POULTRY

PURVIS, MILLER. Poultry Breeding. Chicago: Sanders Publishing Company. $1.50.
WATSON, G. C. Farm Poultry. New York: The Macmillan Company. $1.50 net.
LIPPINCOTT, W. A. Poultry Production. Philadelphia: Lea & Febiger.

MISCELLANEOUS

BOSS. Farm Management. Chicago: Lyons & Carnahan. 90 cents.
WARREN, G. F. Farm Management. New York: The Macmillan Company. $1.75 net.
EKBLAW, K. J. Farm Structures. New York: The Macmillan Company. $1.75 net.
DAVIDSON, J. B. Agricultural Engineering. St. Paul, Minn.: Webb Publishing Company. $1.50.
POWELL, G. H. Coöperation in Agriculture. New York: The Macmillan Company. $1.50 net.
COULTER, J. L. Coöperation among Farmers. New York: Sturgis and Walton Company. 75 cents.

DIRECTIONS FOR MAKING THE BABCOCK TEST

Apparatus for making the Babcock test, including glassware, acid, and directions, may be purchased from dealers in dairy supplies. Following is a list of the apparatus necessary: a 17.6 cc. pipette; a 17.5 cc. acid measure; test bottles; dividers; a water bath; a centrifuge; sulphuric acid, sp. gr. 1.83 to 1.84.

The milk to be tested and the acid to be used should be brought to a temperature of about 70 degrees; this can best be done by means of the hot-water bath.

Following are directions for making the test:

1. Pour the sample of milk from one vessel to another at least five times.

2. Take the pipette between the thumb and the second and third fingers, leaving the index finger free; draw the milk into the pipette immediately after stirring it, and place the index finger over the top of the pipette; now release the finger very slightly until the top of the milk column is even with the mark on the pipette.

3. Hold the milk bottle at a slant and place the end of the pipette in the neck of the bottle, leaving an opening for air so that air bubbles can not form and throw the milk out of the neck; release the finger and allow the milk to flow into the bottle; blow the last drop from the pipette.

4. Fill the acid measure to the mark (never draw the acid into the pipette); take the milk bottle by the neck between the thumb and the fingers of the left hand so that the bottle can be turned; now bring the lip of the acid measure to the mouth of the bottle and pour the acid into the bottle, rotating the bottle so that all the milk will be washed from the neck into the bottle, and holding the bottle at a slant so that the acid will not fall directly upon the milk and thus form pieces of charred curd.

5. Give the bottle a rotary motion in order to cause a gradual mixture of milk and acid; sudden mixing will cause the formation of large amounts of heat and gas, and will throw the material out of the bottle.

6. After the bottle has been stirred thoroughly and the curd is dissolved, place the bottle in the centrifuge and whirl it for five minutes.

7. Place the bottle in a water bath of 180° F. for five minutes, then fill the bottle to the neck with hot water.

8. Whirl the bottle in the centrifuge for two minutes.

9. Place the bottle in the water bath for five minutes and fill it with hot water to within one-half inch of the top.

10. Whirl the bottle in the centrifuge for two minutes.

11. Place the bottle in a water bath, 130° F., for five minutes.

12. Measure the fat column by placing one point of the dividers at the bottom and the other at the top; then, keeping the two points that distance apart, place one point on the zero mark and then note where the other point falls on the scale; the figure on which it falls indicates the per cent of fat in the milk.

Seed Table for Field Crops Adapted to Kansas

Name.	Amount of seed to plant to the acre.	Pounds to the bushel.
Alfalfa (broadcast)	10-20 lbs.	60
Alfalfa (drilled)	8-16 lbs.	60
Barley	4-10 pks.	48
Bean, field (small varieties)	2- 3 pks.	60
Bean, field (large)	5- 6 pks.	60
Beets	4- 6 lbs.	56
Blue grass, Kentucky	25-40 lbs.	14
Brome grass (alone, for hay)	12-15 lbs.	14
Brome grass (alone, for pasture)	15-20 lbs.	14
Broom corn	3- 5 lbs.	30
Buckwheat	3- 5 pks.	50
Bur clover	12 lbs.	50
Carrots (for stock)	2- 6 lbs.	50
Castor beans	.....	46
Clover, alsike (alone)	8-15 lbs.	90
Clover, Japan, or lespedeza (in pod)	2 pks.	.....
Clover, mammoth	12-15 lbs.	60
Clover, red (on small grains in spring)	8-12 lbs.	60
Clover, sweet (melilotus)	10-20 lbs.	60
Clover, crimson	10-12 lbs.	60
Corn	5- 9 lbs.	56
Cotton	4-12 pks.	32
Cowpeas (broadcast)	4- 6 pks.	60
Cowpeas (drilled)	1- 2 pks.	60
Cowpeas (for seed)	3 pks.	60
Duvea	3- 6 lbs.	56
Emmer (miscalled spelt)	4- 8 pks.	48
Field peas (small varieties)	10 pks.	60
Field peas (large)	12-14 pks.	60
Flax (for seed)	2- 3 pks.	56
Flax (for fiber)	6- 8 pks.	56
Feterita	4- 6 lbs.	56
Hemp (broadcast)	14-16 pks.	44
Kafir (in rows)	4- 8 lbs.	56
Kafir (broadcast)	50-80 lbs.	56
Lupines	6- 8 pks.	60
Mangels	5- 8 lbs.	.....
Meadow fescue	50 lbs.	22
Millet, barnyard (in drills)	1- 2 pks.	35
Millet, foxtail (in drills)	2- 3 pks.	50
Millet, German (in drills)	2- 3 pks.	50
Millet, German (for seed)	1 pk.	50
Millet, Hungarian (for hay)	2 pks.	50
Millet, Hungarian (for seed)	1 pk.	50

Seed Table for Field Crops—*concluded*

Name.	Amount of seed to plant to the acre.	Pounds to the bushel.
Millet, pearl (for hay)	8-10 lbs.	50
Millet, broom-corn or proso	2- 3 pks.	.....
Milo	4- 6 lbs.	56
Oat grass, tall	30 lbs.	14
Oats	8-12 pks.	32
Oats and peas—Oats	8 pks.	32
—Peas	2 pks.	60
Orchard grass	12-15 lbs.	14
Parsnips	4- 8 lbs.	50
Peanuts (in pod)	8 pks.	22
Pop corn	3 lbs.	70
Potato, Irish	40-60 pks.	60
Potato (cut to one or two eyes)	24-36 pks.	.....
Potato, sweet	6-16 pks.	50
Rape (in drills)	2- 4 lbs.	50
Rape (broadcast)	4- 8 lbs.	50
Red top (recleaned)	12-15 lbs.	35
Red top (in chaff)	50-60 lbs.	12
Rice (rough)	4-12 pks.	45
Rutabaga	3- 5 lbs.	60
Rye	3- 4 pks.	56
Rye grass	8-12 pks.	20
Sorghum (forage—broadcast)	25-75 lbs.	50
Sorghum (for seed or syrup)	4- 8 lbs.	50
Sorghum (for silage or soiling—drilled)	6-15 lbs.	50
Soy beans (broadcast)	4- 6 pks.	60
Soy beans (drilled)	2- 3 pks.	60
Sudan grass (for hay)	20-25 lbs.	28
Sudan grass (for seed)	3- 4 lbs.	28
Sugar beets	15-20 lbs.	.....
Sunflower	10-15 lbs.	.....
Timothy	12-15 lbs.	45
Timothy and clover—Timothy	10 lbs.	.....
—Clover	4 lbs.	.....
Turnips (broadcast)	2- 4 lbs.	55
Turnips (drilled)	1 lb.	55
Velvet beans	1- 4 pks.	.....
Vetch, hairy (broadcast)	6 pks.	60
Vetch, hairy (drilled)	4 pks.	60
Wheat	2- 8 pks.	60

Planting a Vegetable Garden. The following record, based on work done at the Kansas State Agricultural College Experiment Station, gives data which may be applied in a general way to all parts of the state. There will be a slight variation in dates in the different parts.

Vegetable.	Variety.	Date of setting or planting.	Amount of seed.	Depth of planting—inches.	Distance between rows—inches.	Distance apart in row—inches.	First picking.	Viability of seeds—average number of years.
Beans	Stringless Green Pod	May 10	1 pt. to 50 feet	2 to 3	36	6	June 27	3
	Bush Lima	May 10	1 pt. to 50 feet	2 to 3	36	6	June 27	
Beets	Crosby's Egyptian	April 6	1 oz. to 50 feet	½	12 to 18	2 to 4	June 11	6
Cabbage	Premium Flat Dutch	April 24	1 oz. to 1500 plants	½	36	24	June 27	5
	Early Jersey Wakefield	April 24	1 oz. to 1500 plants	½	36	24	June 27	
Carrots	Early Chantenay	April 1	1 oz. to 100 feet	½	14 to 18	2 to 4	July 20	4–5
	Half Long Danvers	April 1	1 oz. to 100 feet	½	14 to 18	3 to 5	Aug. 10	
Celery	Giant White Pascal	July 13	1 oz. to 3000 plants	⅛	36 to 48	6		8
	White Plume	July 13	1 oz. to 3000 plants	⅛	36 to 48	5		
Cucumbers	Arlington White Spine	May 8	1 oz. to 50 hills	½	48 to 72	48 to 72	July 25	6–10
Lettuce	Black-seeded Simpson	April 12	1 oz. to 150 feet	½	14	3 to 4	May 28	5
	Improved Hanson	April 12	1 oz. to 130 feet	½	14	3 to 4	June 1	
Onions	Giant Gibraltar	April 12	1 oz. to 100 feet	½	12	3 to 4	Aug. 22	2
	Prizetaker	April 12	1 oz. to 100 feet	½	12	3 to 4	Aug. 22	
Parsnips	Hollow Crown	April 12	1 oz. to 200 feet	½ to 1	18	2 to 4		3
Peas	Nott's Excelsior	April 12	1 qt. to 100 feet	3	36 to 42	1 to 2	June 8	3
	Gradus	April 12	1 qt. to 100 feet	3 to 4	42	1 to 2	June 8	
Radishes	Early Scarlet Turnip	March 22	1 oz. to 100 feet	½ to 1	14	1 to 2	May 1	5
	White Strassburg	April 10	1 oz. to 100 feet	½ to 1	14	1 to 2	May 20	
Salsify	M. Sandwich Island	April 25	1 oz. to 70 feet	½ to 1	18	2 to 4		2
Spinach	Victoria	March 25	1 oz. to 100 feet	1 to 2	12 to 18	2	May 11	5
Squash	Summer Crookneck	May 16	1 oz. to 20 hills, or 8 to	1 to 2	84 to 96	84 to 96		6
	Hubbard	June 20	12 seeds to the hill	1 to 2	120 to 144	120 to 144		
Sweet Corn	Mammoth White Cory	April 20	1 qt. to 200 hills, or	2	36	30 to 36	June 23	2
	Stowell's Evergreen	April 20	¼ qt. to 100 feet	2	36	30 to 36	June 23	
Tomatoes	Earliana	May 12	1 oz. to 1500 plants	½ to 1	48	48	July 12	4
	Stone	May 12	1 oz. to 1500 plants	½ to 1	48	48	July 12	
	Dwarf Champion	May 12	1 oz. to 1500 plants	½ to 1	48	48	July 12	
	Trucker's Favorite	May 12	1 oz. to 1500 plants	½ to 1	48	48	July 12	
Turnips	Early White Milan	July 3	½ oz. to 100 feet	¼ to ½	18	6	Aug. 15	5

WEIGHT OF FEEDING STUFFS*

The following table, showing the weight of a quart of each of a number of feeding stuffs, may be helpful in feeding farm animals:

Feeding Stuffs.	Weight.	
	Pounds.	Ounces.
Corn, cracked	1	12
Corn meal	1	8
Corn-and-cob meal	1	6
Oats, whole	1	
Oats, ground		12
Wheat, whole	1	14
Wheat bran		10
Wheat bran, coarse		8
Wheat middlings	1	2
Wheat middlings, coarse		13
Rye bran		10
Gluten meal	1	11
Gluten feed	1	3
Linseed meal	1	2
Cottonseed meal	1	8

Some of these materials, especially by-products like wheat bran, vary considerably in weight, and the figures can not be regarded as strictly accurate for all cases. Weighing is, of course, always preferable where it is desired to feed absolutely definite amounts.

THE SIZE OF SILO TO BUILD

The following table shows the size of silo required to feed various numbers of animals for a period of six months, or 180 days, at the rate of forty pounds of silage daily to the animal:

Number of cows.	Estimated capacity in tons.	Size of silo.		Approximate acreage of corn required.	
		Diameter in feet.	Height in feet.	Eastern Kansas.	Western Kansas.
7	26	10	20	2 – 2.5	4– 5
13	47	10	30	3 – 5	6–10
14	51	10	32	3.5– 5.5	7–11
19	68	12	30	4.5– 7	9–14
21	73	12	32	5 – 7.5	10–15
25	93	14	30	6 – 9	12–18
27	101	14	32	7 –10	14–20
30	109	14	34	8 –11	16–22
33	119	16	30	8.5–12	17–24
36	131	16	32	9 –13	18–26
40	143	16	34	9.5,14	19–28
43	155	16	36	10.5–15.5	21–31
46	166	18	32	11 –16.5	22–33
50	181	18	34	12 –18	24–36
54	196	18	36	13 –20	26–40

*From Farmers' Bulletin No. 22.

DIRECTIONS FOR MEASURING FARM PRODUCTS

I. Measuring Grain in the Bin

Rule: Multiply together the number of feet in length, width, and depth, and take four-fifths of the result, which will be the number of bushels.

II. Measuring Ear Corn in the Crib

Rule: Multiply together the number of feet in length, width, and depth, and divide the result by two and one-half to get the number of bushels. Note: It is usual to calculate a bushel of ear corn in the crib as two and one-half cubic feet if the corn is dry, but if it is new and recently stored, two and five-eighths to two and three-quarters cubic feet should be allowed.

III. Measuring Hay in the Mow or Stack

If alfalfa hay has been stacked or stored in the mow about thirty days, 512 cubic feet are usually regarded as a ton. If the hay has stood five or six months 422 cubic feet, and if it is fully settled 343 cubic feet, will approximate a ton. In very large stacks or deep mows, fully settled, 216 cubic feet are taken for a ton. Hence, to find the number of tons:

(1) In a mow: Multiply together the number of feet in length, width, and depth, and divide the result by the number of cubic feet in a ton.

(2) In a round stack: Find the circumference of the stack at a height that will give a fair average distance around the stack; also find the vertical height of the measured circumference from the ground, and the slant height from the measured circumference to the top of the stack. Take all measurements in feet. Square the number of feet in the circumference; divide this by 100 and multiply it by 8; then multiply the result by the number denot-

ing the height of the base plus one-third the number denoting the slant height. The result is the number of cubic feet, which, if divided by the number of cubic feet in a ton, will give the number of tons.

(3) In a rick: Measure the distance in feet over the rick from the ground on one side to the ground on the other, also measure the width in feet near the ground. Add the two numbers and divide the result by 4; square this result and multiply it by the number denoting the length of the rick. Divide the final result by the number of cubic feet in a ton, which will give the number of tons in the rick.

DIRECTIONS FOR MEASURING LAND

To measure a square or a rectangular field, multiply the number of rods in length by the number of rods in width and divide the result by 160 to find the number of acres. If the field is a right triangle, follow the same rule, but take one-half of the original product and divide it by 160.

The area of any triangular-shaped field where the lengths of the sides are known can be found by the following rule: From one-half the sum of the number of rods in the sides, subtract separately the number of rods in each side. Multiply the half sum and the three remainders and extract the square root of the product. Divide the result by 160 to obtain the number of acres.

The area of an irregular-shaped field may be found by dividing the field into triangles by means of diagonals, finding the areas of the triangles, and then adding the areas found.

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